Science Education

SPECIAL ISSUE ON ELEMENTARY SCIENCE*

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EVALUATION OF SCHOOL BROADCASTS IN SCIENCE

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A project whose purpose is the investigation of the effects of school broadcasts was begun in the fall of 1937 under the leadership of I. Keith Tyler of the Bureau of Educational Research, Ohio State University. This project, limited mainly to the field of school or "educational" broadcasts, is the companion study to the one under the direction of Felix Lazarsfeld of Princeton University, in which the effects of more general types of radio programs are to be investigated. Both of these studies have been made possible through grants from the General Education Board.

In the school or educational-broadcast study, the investigation has been divided into four subject-matter fields: social studies, English, music, and science. The work in each of these fields is primarily in the hands of research associates who have been trained in these respective fields and who have had some experience in the field of evaluation. J. Wrightstone, associate director of the study, is mainly responsible for the general co-ordination of the work in the individual subject-matter fields.

During the first year of the study, approximately sixty teachers, representing Grades V through IX, were organized into three committees. Two of these committees

* *Editor's Note.—At the twentieth annual meeting of the National Council on Elementary Science held in Philadelphia last February, the Council decided to accept the offer of Science Education to have the association use one issue of this journal as a special number devoted to Elementary Science. The January issue was chosen for this purpose. Accordingly, the Editorial Board of the Council has provided for this number of the journal the articles and classroom notes.*

We trust that our readers will find in this innovation both interest and value.

consisted of teachers in and around Chicago. One of these two committees was primarily devoted to the field of health, and the other to science. The third committee represented science teachers in the New York City area. The selection of the committees was determined mainly by the interest and ability of the teachers in the use of radio broadcasts for instructional purposes. The committees were also selected in such a way that teachers of rural schools would be represented, as well as those from large city schools. Those persons in charge of certain broadcasts, such as the "Your Health" series and the American School of the Air Science Broadcasts, are also members of these committees.

The procedure in the committee meetings was based on the assumption that teachers are using certain of the broadcasts to further their aims for purposes of teaching. Therefore, before any formal evaluation could be attempted, it was necessary to spend considerable time with the committees in clarifying the purposes and aims considered by the committee to be important for health and science instruction. In other words, in attempting to appraise or evaluate the effects of the use of radio broadcasts, the attempt is made to measure as many as possible of the outcomes of the "whole" program of health or science instruction. Then, through the use of control groups in which the program of instruction and the pupils are as nearly identical as possible, the only difference between the two groups being the use of the broadcasts, it should be possible to infer the effects of those broadcasts. This plan of beginning with the purposes of the entire program of instruction was followed mainly for two reasons. First, those in charge of the production of the broadcasts hesitate to make any statement as to what they expect to result from the use of these broadcasts. Second, even though the purposes of the broadcast may be rather clear to those who are planning broadcasts, nevertheless, there may be certain effects resulting from the use of the broadcasts which may be entirely unpredictable.

This technique of procedure was also particularly helpful to those in charge of broadcasts, since it was possible for them to obtain some idea as to those purposes and outcomes of health and science instruction which teachers consider to be important. For example, most of the members of the science committees agreed that radio broadcasts could serve them best if broadcasts were planned which would meet some of the principal inadequacies of instruction. This may be illustrated by the fact that most science teachers do have considerable laboratory facilities, whose purpose it is to demonstrate or illustrate certain science principles or generalizations. These teachers felt, therefore, that radio broadcasts which duplicate this type of work—that is, broadcasts which were devoted mainly to illustrating or demonstrating certain principles—would not be particularly helpful. They believed the more direct experience which they already had available in their classrooms and laboratories would be better for developing a knowledge of principles and understandings than would the use of broadcasts. These same teachers also pointed out some of the principal inadequacies of their instruction to which the radio might make a contribution: first, the lag between new or current science developments and discoveries and their appearance in the classrooms. Very often these new discoveries find their way into science or health textbooks only after several years have elapsed. These developments also usually appear in textbooks in a rather denuded form; that is, the possible consequences or implications of these discoveries are not adequately described when they do appear in textbooks. The members of the committee, therefore, indicated that they would like to have broadcasts available which would keep their classes more up to date with respect to new developments

in the field of science and health. Second, certain "taboo" or controversial questions not present in science or health programs of instruction. Such questions as those of the difference between the cost of producing electrical power and the cost to the consumer, of providing adequate medical care, and of the dangers and implications of social diseases, represent issues which are not commonly discussed in health or science classes. The members of the committee believe that radio broadcasts could be devised in which people who are adequately informed concerning these issues could present them in such a way that a significant contribution would be made to the program of instruction. Third, the inadequacy of a sufficient number of "field" trips. Because of the pressure of compact schedules and the difficulty of taking care of a relatively large number of students, most science teachers have found it particularly difficult to have their students see illustrations of science principles and the applications of those science principles in actual practice. Trips to electric power plants, telephone exchanges, hospitals, farms *et cetera,* are relatively few in the usual program of science instruction. The members of the committee believe that more broadcasts should be available in which the microphone is taken directly into these places. Most of the teachers agreed, of course, that this experience would not be as valuable as a visit by the class. But since the class visits are too few, they agreed that this practice of visiting the hospitals, the power plant, or the telephone exchange, via the radio, would be a good substitute.

The purposes, or aims, which were considered by the committee concerned with health instruction to be most important in connection with educational broadcasts may be divided into two types: those dealing with certain attitudes and appreciations, and those dealing with critical thinking and discrimination.

1. *Attitudes and Appreciations*

To recognize that it is possible to be healthy without excessive concern about health.

To develop the attitude or willingness to encourage research in medical practice.

To recognize that health knowledge is partial or relative and not absolute, that there are no final answers. . . .

2. *Critical Thinking and Discriminations*

To develop the ability to check on health data and to make accurate interpretations of health data.

To develop the ability to ascertain qualified health authorities.

To develop a scepticism of the frauds and fallacies in health. . . .

The members of the committee then proceeded to indicate instances of pupil behavior which they thought to be illustrative of success in attaining these objectives.

In the field of science, the objectives or purposes considered to be most important in connection with educational broadcasts may be divided into three principal types: attitudes and appreciations, interest and self-motivation, and critical thinking and discrimination.

1. *Attitudes and Appreciations.*

To recognize that truth is partial and not absolute, that truth changes. . . .

2. *Interests and Self-Motivation*

To develop an interest in scientific discoveries and developments. . . .

3. *Critical Thinking and Discrimination*

To develop habits of critical thinking. . . .

These statements of purpose were also clarified by instances of students' behavior which should result if the teacher were to consider himself successful in attaining these purposes.

The two principal types of evidence to be collected, which should reveal the extent to which these purposes are being realized through the entire program of instruction in health or science, are anecdotal records and achievement tests. Six achievement tests were devised in the field

of science to measure progress in some of the purposes mentioned above. The exploratory use of these tests in the spring of 1938 showed that it is possible to collect evidence concerning such things as pupil interests and critical thinking in Grades V through VIII. Information concerning the characteristics of pupils which these tests reveal may be obtained directly from the study "Evaluation of School Broadcasts" (Ohio State University).

A considerable amount of time was spent in the committee meetings during the year in discussing the utilization of radio programs. It is almost self-evident that the extent to which a radio program produces results depends upon the preparation and also the extent to which the teacher follows up those ideas which the broadcast has presented. Certain of the broadcasts, such as the "Your Health" series, are very well outlined previous to the time the broadcast takes place. The outlines for these broadcasts appear in the magazine *Hygeia*. In the case of these broadcasts, it is entirely possible for the teacher to go over certain words which will be used in the broadcast. In this way, he tries to insure that the purpose of the broadcast will not be defeated because the students do not understand certain technical words.

Evidence concerning the effectiveness of educational broadcasts is being gathered this year in several different ways. In some of the studies, a control group in which the radio is not used at all is matched against an experimental group which just listens to the broadcast without any preparation or follow-up. In other investigations, a control group is matched against an experimental group with which the teacher spends as much as an hour weekly in preparing the class for the broadcast and following the broadcast with a discussion of the ideas which it presented. In still another type of study, the control group only listens to the broadcasts; whereas the experimental group with which it is matched is one in which there is a considerable amount of preparation and follow-up for the broadcasts. In all of these studies, the teachers are keeping a record of the techniques employed in using the radio broadcasts.

It is hoped, therefore, that from these investigations teachers who are concerned with the use of this new educational tool will be in a better position to know what to expect from its use. If the results of the investigation show, for example, that certain desirable attitudes are significantly effected through the use of radio dramatizations, the teacher would probably want to use radio broadcasts for developing those attitudes, rather than some other technique such as reading or laboratory investigation, which probably would not be so effective for producing the same result.

WHAT CAN THE ELEMENTARY SCHOOL CONTRIBUTE IN A CONTINUOUS SCIENCE PROGRAM?*

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Science has worked its way down through the schools. College physics came to the high schools with a little mathematical shortening and a few minor alterations. Chemistry was likewise cut down for younger members. There is this difference in the comparison, however, with the older brother's clothing that our mothers made over for us: we never had to wear the same clothing unaltered when we grew older. The college chemistry and physics teachers, on the other hand, were soon faced with the problem of what to do with entering students who had already worn the same mental apparel. Some institutions enrolled in advanced classes those who had studied these sciences in high school. Others decided that perhaps clothes did not make the man anyway, and fitted the student into the same garments again.

Botany and zoölogy came down to the high schools in a similar manner. Later they were not only altered but made over, some of the essential principles of these sciences being incorporated in a biology course. Incidentally, the style of this new garment has not changed greatly since it was first designed and is badly out of date. Moreover, a strange phenomenon has occurred in that the made-over garment is being handed up instead of down. We college teachers are adopting it for our general students. The difference in objectives and scope between high-school and general college courses in the biological sciences has never been clarified.

When science found its way to the ninth grade, about 1912, a still larger question was raised as to the proper nature and functions of science teaching at the various levels. In fact, the matter loomed so large in the field of science teaching that something approaching a reorganization took place, though only at the lower levels. The first books in general science consisted of sections from the various special science texts written down to the ninth-grade level. Considerable reorganization has since taken place, first under a series of general units, such as "air" and "water," and later under experience units. The development of general science stands out in the history of science teaching for its departure in selection of content and method toward obvious design for use.

Since that time, science has been introduced rather generally into the seventh and eighth grades, with the result that many teachers as well as pupils are sorely puzzled as to what differences exist between seventh-, eighth-, and ninth-grade science. In many courses of study in junior-high-school science the same units appear in two or more grades with little indication that distinctly different experience approaches are to be employed. Now that elementary science is finding its way into all grade levels of the elementary school, many of the units that are being organized are strikingly similar to those already in use in junior-high-school science. The introduction of science into the earlier years is causing teachers to question the suitability and grade placement of the work that is being done at all levels. The inclusion of science in elementary-school curricula will inevitably influence science training in the secondary schools and colleges. This is true whether we regard training in science as attaining self-

* Paper presented before the General Science Section of the Wisconsin Education Association at Milwaukee, November 4, 1938.

direction along the lines of social and personal need, or traditionally as the acquiring of essential knowledge. In considering the suitability of the science program at any level, whether it be eighth-grade science or the survey course at the Freshman college level, it is important to know the nature and extent of previous science training. Junior-high-school, senior-high-school, and college teachers may expect a progressive change in the preparation of the pupils entering their classes from year to year. It may be a bit unsettling, but there is a certain advantage in being forced to reorient ourselves frequently and to change our courses of study continually.

Recently in many elementary schools throughout the country, science has been placed on a basis co-ordinate with other phases of the curriculum. While some of these elementary-science programs are possibly undeveloped and ineffective as compared with those in other fields of childhood education, it is reasonable to assume that they will become more purposeful and functional. Teachers will become more familiar with the field and more confident and active. Programs will be evaluated and redirected. Better-trained teachers in science will come into the schools.

All of this calls for more consideration of the functions of science teaching at the various levels. When a pupil reaches the senior-high-school science level, what can we reasonably assume that he has already achieved in the way of scientific and social attitudes as well as concepts and abilities to do useful things? What can science in the elementary school contribute toward these important ends of science education? It is this phase of the problem, in particular, that I have been invited to discuss.

Before proceeding further with the discussion, we must realize that we do not possess sufficient evidence, based on careful researches, to solve the problem. We do not know what children in the elementary school can achieve in the field of science. In fact, it is doubtful whether anything approaching an absolute solution is possible on account of the many variable factors: conditions change, local needs vary, children vary greatly in abilities, philosophies are evolving.

On the other hand, there are mounting evidences that the elementary-school child is capable of creditable work in science and of growth through science study. He exhibits very positive, if somewhat transitory, interests. He wants to manipulate, to experiment, to explore, to grow plants and rear animals. He may not be greatly interested in the inherent nature of his environment, but he is decidedly interested in what he can do with it. Moreover, he is reasonably able to generalize where he has the necessary experience basis for the generalizations.

The interests and abilities of the child are, however, only one of the essentials for effective work in elementary science. The other is the provision of suitable opportunities by the schools. In order to provide suitable opportunities, we need, first of all, teachers with vision, who see the child as a stranger in a world as bewildering and seemingly chaotic as it was to early man—teachers who see science as a quest in which man is gradually finding his way through the blinding fog of ignorance that shrouds everything in mystery, and who see the science program as a way of providing challenging and significant experiences by means of which the child orders his world. It is important that teachers, in addition to being fervently imbued with the spirit of science and of science education, have some knowledge of scientific concepts, methods, and materials. The chief limiting factor in determining what the elementary school can contribute in a continuous science program seems to be the training of teachers. Children are eager and able to undertake in an elementary way the quest which makes science the great modern adventure, but will there be teachers able to direct this quest?

Perhaps the problem of securing good teachers is the greatest problem at all levels, but it is certainly more acute at the elementary-school level, for elementary-school teachers obviously cannot be expected to major in science. Teacher-training seldom anticipates a demand. There is a strong tendency to train for the schools as they are rather than as they ought to become. All of this tends to delay provision for suitable opportunities for children in the field of elementary science.

Teachers will seek preparation to direct elementary-science work and will lend their energies to it somewhat in proportion to the relative emphasis which school authorities place upon that field of effort. School authorities, in turn, tend to insist upon a well-planned program with teachers able to direct it before they will approve a larger place for science in the elementary-school program. There is thus a cycle of administrative organization of the school program: schoolbooks, etc., schoolroom, teacher-training, and administrative evaluation. Each phase of the cycle conditions and limits the others, but it should also be noted that change in any one phase is likewise capable of bringing about changes in the others. This seems to be taking place now in the long-overdue movement in science and the social studies. In elementary science, textbooks and supplementary materials, journals, school programs, courses of study, school practice, and teacher-training programs all evidence a leaven that is working to introduce the child to an elementary understanding of his world. It represents a new day and a new deal for childhood when the stress on verbalism and formalism gives way to experiencing and understanding.

We may now expect science to gradually take its place as one of the principal fields of elementary study or as an important component of the integrated program. In some schools it has already attained this stage in development. What outcomes may we reasonably expect from science work in the elementary school and what bearing will they have on science work at higher levels? Perhaps it is too early even to predict, although the matter cannot be overlooked. Junior-high-school science teachers may expect to be constantly reminded by their pupils of work done in the elementary school. For example, in a widely adopted elementary-science series, a recently published book designed for use in the fifth grade devotes nine pages to pulleys, six to levers, twenty-two to the effect of heat on materials, thirty to weather, twenty-seven to food manufacture and relationships, twenty-eight to reproduction, etc. This illustration is cited only to show the extent to which matters commonly considered in junior-high-school science have found their way into elementary science. It is not the purpose here to attempt a critical evaluation of textbooks or courses.

When we try to estimate the possible outcomes of elementary science, we do not think primarily in terms of contributing learnings, but rather in terms of avenues of interest and satisfaction opened, scientific and social attitudes developed, outlooks changed through concepts comprehended, and abilities developed to do useful things. It is very difficult, though probably not impossible, to measure achievement along these lines. It is to a considerable extent a matter of gradual growth. The suggestions that follow are, therefore, based more on experience and observation than on controlled investigation.

It would seem that a considerable contribution can be made in the elementary school toward opening avenues of satisfaction and leisure interest. It is not necessary to wait until high-school age or adulthood to learn to find satisfaction in following seasonal changes, bird migration and nesting, the flowering and development of common plants, the weather, the ways of wild life, and similar simple joys. In the teacher-training institutions we are devoting part of the biology periods to at-

taining an elementary recognition of the commonest birds, trees, herbaceous plants, and insects, and to developing interests for recreation as well as social attitudes that make for conservation. There is considerable reason to believe that these interests can be developed more naturally during childhood. The same may be said of making simple collections, rearing insects and pets, observing the heavens, growing plants, and many forms of creative expression. There may be some who will not consider these to be outcomes of science teaching, but it is reasonably certain that ability to find recreation is rapidly becoming one of the major aims of education.

When we consider the possibilities of developing scientific attitudes through elementary science, it is important to realize that they are specific to a considerable degree. One may exhibit scientific attitudes in certain situations and fail to do so in others. This is but another way of saying that we need to develop scientific attitudes in the various life situations. Foolish fears of harmless creatures are developed at an early age. On the other hand, children show a surprising ability to distinguish between what is true and what is "make-believe," which is more than can be said of adults in certain situations. Curiosity, one of the most important elements in a scientific attitude, is markedly present in most children, and is generally held to be stifled by adult repression. Set opinions and prejudices should be less deep-rooted. Bored satiety is lacking. Much of the work of the traditional school, with its emphasis on handing back printed and oral statements, could hardly be expected to develop scientific attitudes. However, conditions in general seem favorable for development of these attitudes. What a well-planned elementary-science program can contribute toward this desired outcome remains to be demonstrated.

We know even less about the growth in comprehension of scientific concepts, although they have served as the central ideas about which a number of elementary-science textbooks have been written. The importance of scientific concepts in determining the outlooks of mankind are unquestioned. To what extent our science courses are effective in developing functional comprehension of concepts we do not know. The assumption, based on the work of Haupt [1] and others, is that science concepts are matters of gradual evolution in an ever widening sphere of significance, and that there are levels of comprehension which may be achieved as the child progresses. We have recently been attempting to secure and study statistically a tangible expression of the development of one of these concepts, that of the duration of time, in pupils from the first grade through the senior college; but we are not ready to present our findings at this time. The whole problem of the development of concepts is in such a pioneer stage that it is impossible to predict at present what the study of science can contribute at any level. There are simple contributing elements of many of the commonly held concepts of science that seem suited to the elementary-school level.

The development of social attitudes and actions is such a paramount need that education in all fields and at all levels should be directed toward it. In addition to the development of broader social outlooks which should be furthered in the elementary school, there are a number of specific social needs toward which it would seem that elementary science could make valuable contributions. There is need on the part of children as well as adults of conserving wild plants, lawns, parks, beneficial and harmless forms of animal life, clean waters, and interesting natural habitats. There are social attitudes to be developed in matters of sex and reproduction, home and community hygiene, and public safety. One of the most important

[1] G. W. Haupt, *Experimental Application of a Philosophy of Science Teaching in an Elementary School.* Contributions to Education, No. 633. New York: Teachers College, Columbia University, 1935.

is co-operation, which group projects in elementary science can foster.

Elementary science can also make many contributions to the child's ability to do the things that are important for his own protection and benefit. Children carry on many of the same activities, use many of the same materials, and face many of the same dangers that older pupils and adults do. There are habits and practices to be developed that make for personal health. There are safety measures to be understood and practiced. Telling direction; building a suitable outdoor fire and extinguishing it; caring for roller skates and bicycles; using a telephone efficiently; purchasing toys wisely; caring for clothing; caring for a room, including regulation of ventilation, light, and temperature; growing plants; and caring for animals are some of the useful things that children may come to do better through a well-planned elementary-science program.

In conclusion, one guiding principle stands out clearly. Elementary science should not be a poor imitation of secondary-school science, achieved by cutting down the latter. The only worthy considerations are the needs of the child as a developing social-biological organism and those of society. A good beginning has been made toward defining these needs. What we need most urgently now is a wealth of richly suggestive procedures to enable busy teachers better to achieve these goals.

TEACHING A GENERALIZATION OF SCIENCE *

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An analysis of recent articles and committee reports dealing with elementary science reveals a noticeable shift in emphasis. Nature study, as science in the grades was formerly called, is being replaced largely by true elementary science. In other words, the emphasis is moving away from "the simple observational study of common natural objects and processes for the sake of personal acquaintanceship with the things which appeal to human interest directly." [1] Instead, teaching is being focused upon an understanding of the principles and generalizations of science that ramify most widely into human affairs.[2] Such a change in objective naturally demands a corresponding change in teaching method.

Let us assume that we are trying to teach a principle or a generalization of science. Is there a pattern of teaching which is usuable with this or any other principle? Can we analyze the procedure into definite steps which may be employed with any principle? Furthermore, can we so formulate our pattern of teaching that if the pupil follows through the steps of the teaching procedure, he will be getting practice in habits of good thinking? In this article an attempt will be made to outline a procedure which will accomplish these aims.

Let us assume that we are trying to teach that there are certain requirements for burning. First we will ask ourselves, "What experiences have these pupils had which may furnish a starting point?" For example, pupils have had many experiences

* Reprinted from *School Briefs* (Scott, Foresman and Company), I: 2; November, 1937.

[1] M. A. Bigelow, *Nature Study Review*, I: 16; 1905.

[2] *Thirty-first Yearbook of the N.S.S.E.*, Part I, "A Program for Teaching Science," pp. 42–43, 1932.

with building, tending, or putting our fires. Our first question will deal with a recall of these experiences. Then we will press the pupil for explanations of these experiences. We will push him back and back until we reach the point where he can no longer explain why certain happenings take place. As these questions are reached, they are written on the board. Such questions might be as follows: "Why do small pieces of wood catch fire more quickly than large pieces?" "Why do some materials burn, while others will not?" "What becomes of the wood when it burns?" "Is all of the air or only part of it used in burning?" "Why do some materials burn with a flame, while others do not?" These questions provide real problems to solve because they are related to everyday experiences the child has had.

To solve these problems it is of course necessary to have an understanding of the requirements for burning. Experiments may now be performed by the pupil or demonstrated by the teacher. The pupil may be sent to books to clarify further the ideas obtained by experimentation. As a result of this study, the requirements for burning are formulated, and the problems raised in the earlier discussions are solved.

It is at this point that teaching usually stops. We are likely to assume that the pupil now has a functional understanding of the idea. Actually he has only arrived at what one may call the "point of apprehension." That is, he catches the idea in a general way and sees that certain conditions are necessary for burning. Left at this point, however, this learning soon fades away.

If the idea is to be made functional, the pupil must be able to use it to explain or interpret other situations involving similar conditions. He must be led to see that this idea, principle, or generalization of science is not only useful in solving problems already presented, but that it is a basis of explanation for all situations in which burning does or does not occur.

At this point the teacher should present situations of an environmental character which can be explained by the idea presented; for instance, "Why is it necessary to strike a match?" "When a hard-coal fire goes out, why is it difficult to start it again?" "Why do you blow on a fire to make it burn and blow on a match to put it out?" "Why does dry wood burn more readily than wet wood?" It is through practice in interpreting such situations that the pupil finally comes to accept the principle as a method of explanation and to acquire skill in its use. In other words, a functional understanding of the idea can result only if the pupil has had sufficient practice in the use of the idea to be able to recognize in problem situations the elements which identify them as being explainable by the idea. Once he discovers that the situation deals with the requirements for burning, he has only to recall these requirements and compare them with the conditions present in the new situation. The likenesses or differences discovered provide a basis for explanation.

There are thus three steps in the teaching pattern: first, raising problems through questions concerning experiences which pupils have had; second, presenting the idea or principle which will solve these problems; and third, providing practice for the pupils in using the ideas to explain other common happenings.

METHODS OF TEACHING SCIENCE TO CHILDREN

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So little experimental work has been done in the field of elementary science that one hesitates to set up a method of teaching it. As more research is done, we shall have a more scientific basis for our statements. The philosophy I shall discuss has grown out of an attempt to use the suggestions of elementary-science specialists in the classroom. It is not a static philosophy. It is as flexible as the subject itself. Science-teaching has to keep up not only with the discoveries of science but with progressive ideas in education.

Education no longer accepts subjects as a part of the curriculum without challenging them. Science must prove that it functions in the lives of children. It must adapt itself to the progressive ideas of child development, yet keep its feet on the ground.

As teachers of science we need to examine ourselves pretty critically and ask ourselves the questions: "Does my science teaching meet real needs in the lives of children?" "Is it helping them to develop into useful members of society?" "Is it giving them opportunities for developing their abilities?" "Or am I still thinking in terms of subject-matter units?"

If we are thinking in terms of children, we must consider these questions:

1. What science facts and principles contribute to the everyday living of the children we teach?
2. What problems in science do these children need to solve?
3. How can we best help children solve these problems?
4. What desirable appreciations, attitudes, habits, and skills may children develop in their science activities?

What science facts and principles are a part of your children's lives will depend on several factors. One of these factors is the environment of the children.

The children in a little school of a high mountain valley may use oil lamps, wood fires, and water from a stream. To them electricity might mean batteries and lightning. But they may wonder how a modern oil lamp works and need to know how to use storage batteries.

The children in an industrial city might wonder about smoke and how to eliminate some of it. Their homes might be heated with oil, coal, or gas, and lighted with electricity. They might use electricity for cooking.

All of these children are affected by the problems of how we get heat and light. If they solve the problems for their own environment they may be led to an interest in the bigger problems.

The racial backgrounds of the children we teach constitute another factor influencing our choice of science facts and principles. This is especially true when the children do not speak English easily or understand it. Since they are trying to learn the language, the science concepts must be very simple at first. They must be clearly presented with as much illustrative material as possible. Science may aid in teaching language if the teacher uses accurate experiments and careful technique to establish the concepts. Many American-born English-speaking children come to school with inaccurate concepts of such words as "steam," "flower," and "bat." It is often easier to teach a correct concept to a child who has none than to correct an inaccurate one. The teacher must also remember that inventions many children accept as a matter of course may be real problems to children who have not grown up with them.

Still another factor influencing the science we choose is current happenings. Even little children are aware of many of these through radio, newsreels, and the conversation of older people.

We can no longer say with any authority that this portion of subject matter belongs at one age level and that portion at another. Certain phases of a subject may appeal to one age level more than to another, but we are not certain about the most effective age at which to present any given phase.

These factors all influence the choice of subject matter. It will vary with locality, individual differences of children, and current changes in the world of science. There is here nothing very definite to guide the inexperienced teacher, is there? She is probably wondering how she may begin a science program. Is it to be a hit-or-miss sort of thing? Will she wait for Tom or Susan to ask what makes an electric light work before she starts her science? Or until Johnny brings a turtle to school?

Fortunately there are certain science experiences that are common to everyone and concerning which most children have questions.

For example, children are always interested in the seasonal changes of plants, animals, and weather. The scientific principle that living things survive because certain modifications of structure make it possible for them to adjust themselves to the environment has many practical approaches. Perhaps you teach in a rural school. What problems in your environment help to develop this principle? These may illustrate:

1. How are wild mammals able to live through the winter?
2. What changes are taking place in plants that make it possible for them to live through the winter?

The solution of these problems might involve varied activities depending on the individuals in your group. For example, if woodchucks, squirrels, and rabbits are common in your region, their habits will help solve the problem. If prairie dogs, ground squirrels, and jack rabbits are common, these will help. If none of these are common, perhaps skunks, muskrats, beavers, or badgers may be studied. Wherever there are wild mammals—even mice—the problem is pertinent.

Were the problem enlarged to wild animals, the possibilities would be increased. The younger the children, the wider the variety of forms you may discuss, and the less exhaustive will be the study of them. For instance, span must be taken into account.

But, you ask, how am I to choose, from all of the interesting problems that might arise, which ones to teach? Perhaps these few criteria may help you in the choice of a unit:

1. Is it worth while from the standpoint of its functioning in children's lives?
2. Is it challenging?
3. Is it within their ability? Will it stimulate the thinking of the superior children yet have appeal to the duller ones? Does it present an obstacle in their thinking, yet not a barrier?
4. Is the material available with which to present it?

Having decided upon a unit and your major problems, what shall you do next? As a teacher, you need to plan your procedure. How are you going to introduce the problems so that they will arouse real curiosity on the part of the children and a desire to engage in the solution? Shall we illustrate with a concrete example from one of the intermediate grades?

The teacher had in mind the development of the principle of interdependence between living things. The major problems that she hoped to help the children solve were:

1. How do animals and plants need each other?
2. How do animals need other animals?
3. How do plants need other plants?

The teacher planned to use several small units to help in solving these problems. Examples of these are:

A. The inter-relationship between bees and plants.
B. Other social insects.
C. Insects harmful to man.
D. Birds that help man.

She had prepared material on bees for her introduction. The first day of school a child brought a beautiful banded garden spider to school. Some of the children were afraid of it, so the teacher saw an excellent opportunity to develop the scientific attitude of basing conclusions on facts and not upon hearsay; also to remove an unreasoning fear and to establish a respect for the good that spiders do. She therefore let the child show his spider and encouraged a discussion. While she held the spider on her hand so they all could see it, the children asked their questions and gradually drew nearer. As their fear was replaced with confidence, the teacher led them to realize that one must use care in handling spiders, just as one must be careful in handling any animal that might bite or sting. They were shown how they might capture a live spider in a glass jar if they wished to study it. They were cautioned about the one poisonous spider, the black widow, that is found in the region.

Some of the children's questions were:

1. How do spiders eat?
2. Where does a black widow spider keep its poison? How sick would you be if it bit you?
3. How can you tell a black widow spider?
4. How do spiders make their webs?
5. How do spiders have little spiders?
6. How many kinds of spiders are there?

The questions were listed on the board, and the children discussed ways of finding answers. The activities suggested and carried out were:

1. Looking for different kinds of spiders and watching them to see what they are doing.
2. Watching spiders making their webs.
3. Reading in *Pathways to Science*, Book V.
4. Putting the garden spider into a large terrarium where it had room to spin a perfect web.
5. Posting pictures of spiders' fangs, spinnerets, and eyes. Also other pictures from the *National Geographic*.
6. Extracting the black widow's fangs and mounting them under low-power microscope.
7. Making a terrarium for other spiders brought for study.
8. Going on a trip to the garden to look for garden, crab, and wolf spiders.

These activities were shared by teacher and children. Some were suggested by the teacher, but most of them were suggested by the children.

The material was summarized when the children wrote the answers to their questions after an oral discussion. Emphasis was directed toward the aspects showing the interdependence between spiders, insects, and man.

Through a question that arose as to whether a spider would kill a wasp or the wasp a spider, the children became interested in mud daubers. Their first reaction was to jump to a conclusion concerning this question. A college student had captured a black widow spider and put a yellow jacket wasp in with it. She had watched the spider kill the wasp, and related the experience to the children as she showed the jar with the live spider and dead wasp.

Ann said, "That answers our question about whether a spider would kill a wasp or not."

Jack, "But that wasp couldn't get out of the jar and was caught in the web."

Glenna, "Perhaps the spider would have caught it in its web anyway. See, the spider has wound threads around the wasp."

Dan, "You—can't tell what would happen if they were outdoors."

The challenging of statements made by children who make snap decisions, is evidence of developing scientific attitudes. In this instance, the teacher finally questioned the children as to whether we could decide that all spiders would kill all wasps

just because one spider killed one wasp. Then she suggested that some wasps might kill some spiders. The suggestion led to reading about wasps and a study of their relation to living things.

In the development of a unit we may follow a skeleton plan:

I. Major problems
   A. Minor problems, resulting from the analysis of the major problems. These are actually the questions the children ask.

II. Solution of the problems
   A. Activities by which the problems are solved. These should be as interesting as possible and should be carried out by the children where practicable. Sometimes, if apparatus that needs care and accuracy in manipulation is used, a demonstration is given by the teacher with the assistance of the children.

III. Outcomes we expect to get in terms of appreciations, attitudes, skills, habits, and knowledge.

Since a unit should be a shared experience, the details of its development will be modified as it progresses. The teacher needs to be continually alert to ways of using the children's contributions. Children should be encouraged to give their ideas and observations and made to feel that any conclusion based on careful thinking is worth the consideration of the group.

What outcomes should be expected from science teaching? In the units just suggested, there were many opportunities for developing appreciation—not only the kind that comes from the appeal of beauty, but appreciation that grows out of an understanding of the balance of nature. Children who have studied bees at work in a flower garden and solved the problem of how bees help plants have an intelligent appreciation of that partnership. We hope that, as college freshmen, they will not think that the main function of a flower is beauty.

Although I think appreciation is a very important outcome, I think the outcomes that science can expect to achieve—perhaps to a greater degree than does any other subject in the curriculum—are scientific attitudes and methods of problem-solving. Every science lesson should offer opportunities for the development of these outcomes.

Teachers not trained in science may have more difficulty in achieving these outcomes because they themselves have not had the opportunity to develop them.

What is a problem? How does one set up problem-solving lessons?

First, by creating problem situations: by placing an obstacle in the children's thinking—an obstacle that will challenge them but not baffle them. An example may help illustrate the point.

The teacher wished to introduce this problem to a sixth grade: "How do rocks help interpret the history of the earth?" She had brought some pieces of fossiliferous limestone to show the class. She told the children that she had found them in an old stream bed and asked, "Why did I look for fossils in the river bed instead of on the tops of the hills?" As these children had some knowledge of fossils, they were able to attack this problem and solve it. To children with no background, the problem would have been an insurmountable barrier. To such a group, the teacher might have given this problem: "How did these prints get into the rocks?"

Often the problem will be stated by a child if the teacher presents the material. For example, a child told of his trip to the La Brea pits and remarked, "There were people from all over the country studying those fossils." Another child immediately asked, "Why?" The teacher wrote the problem on the board, "Why

do scientists from different parts of the country go to the La Brea pits?" A very profitable period was spent in the solution of the problem.

In using the problem-solving technique with children, we have to be very careful to work psychologically and not logically. For example, a child brought a round stone and showed it to the group. Their question was, "How was the round stone formed?"

The teacher recognized a concretion and might have made the mistake of beginning with her knowledge. She might have said, "Where do you think the stone was made?" "How do you suppose the material got into the hole?" This would have been an analysis and might have led to a solution. But very likely most of the data would have been the teacher's contribution.

Instead, this was the procedure:

Problem: How was the round stone formed?
Analysis:
- Teacher's question: What can you tell by looking at the stone?
- Children's answers:
  1. It has something like cement on the outside.
  2. Perhaps it is limestone.
  3. It feels sort of gritty.
  4. It seems to have sand grains in it.
  5. What would make sand stick together?

Hypotheses:
1. Perhaps it is limestone made in a cave.
2. Perhaps it is sandstone made round in a stream.

Solution: Gathering data.

The teacher and children discussed their observations and past experiences. The child who had suggested that the stone was limestone asked to be allowed to do the HCl test. As she worked, the children suggested that she test it in a broken spot as well as on the outside. They broke off sand grains. Since there was no available reading material on their level to complete their data, the teacher helped by drawing diagrams on the board to illustrate the formation of concretions. She connected it with their experience in as many ways as possible. The deposit on the sides of a teakettle helped.

Results: The stone reacted to HCl. It had sand in it.

Conclusions: The children decided that the stone was limestone with some sand in it, that it was formed by water with lime dissolved in it, cementing a few grains of sand as a center. Others collected around it and were cemented to it.

This particular solution followed all of the steps in problem-solving in a very simple fashion. Many problems that children solve lack the detailed steps in the problem-solving technique. But so do most of the practical problems of everyday life. How many of us set up hypotheses that we test experimentally in practical situations? We analyze our problems in the light of our experience and draw conclusions. Only if the conclusions are incorrect do we go back and look for other possible solutions.

An example of the confusion in problem development which results when the teacher disregards the psychological approach arose in a lesson on owls.

The teacher put this question on the board: "When an owl awakens in the sunlight, what happens to its eyes?"

Her aim was to teach something about the structure of the owl's eyes. The children were bewildered by the question because they did not know anything about the structure of eyes. It was not their problem and did not touch their experience. The lesson was a failure and everyone was unhappy.

The next day the teacher started with the children's questions, "Why do owls sleep in the daytime?" and "Are owls blind in the daytime?"

They discussed the owl's habit of feeding at night. They compared them with people who work at night and sleep in the daytime. The children recalled what happened to their eyes when they had been asleep and opened their eyes to look at a bright light. They studied their own eyes and discovered that the pupils change size

with varying light. They compared their own eyes with an owl's and a cat's eyes. The teacher had accomplished her aim, and the children were enthusiastic throughout the solution of their problems.

It is equally important when developing a physical principle that the concepts presented be arranged in order of their complexity.

For example, in solving the problem of what causes wind, the adult may think at once of convection and decide to demonstrate by means of a convection box. He lights the candle, holds his smoking paper near the cold-air chimney and wonders why the children do not draw correct conclusions from the experiment. Perhaps those children have so few concepts of air, or such inaccurate concepts, that they cannot draw correct conclusions.

A teacher needs to begin at the bottom and establish a common basis for her experiment. Find out whether the children know these things about air:

> Air is (that is, exists).
> Air surrounds us (occupies space).
> Air presses (has pressure).
> Air takes up more room when it is heated (expands).
> Air takes up less room when it is cooled (contracts).
> Gravity holds air to the earth, just as it holds us.
> Gravity pulls the heavier cold air more than the lighter warm air.

Not until the child has performed simple experiments demonstrating these concepts is he ready for "currents set up in the air by unequal heating." I really believe high-school science-teaching would benefit by such a procedure.

Let me hasten to warn any teacher against trying to do more than one of these experiments at a time, or having the apparatus for more than one in sight. She should have only the things she wishes to use in the experiment. Otherwise the attention of the children will be distracted.

For example, a teacher wanted to help the children solve a problem: "How did the fossil get into the rock?" The fossil in question was a lamellibranch. She had a live clam in a jar, a clamshell, some coquina rock, and the fossiliferous limestone. Instead of discussing the fossil first, with the other things out of sight, she put all four on the table and asked the children whether they could see the connection. A sixth grade might have responded to such a challenge. The third grade was confused. They had no basis for comparison. They should have discussed one thing at a time and make their observations; then they could have made comparisons.

Science-teaching in the grades requires no elaborate equipment. Materials available in any community and a few cents spent at the ten-cent-store will supply ample opportunity for good science-teaching. One girl I know taught science in six grades of a city suburban school. In two years she spent $1.59. It required an alert, enthusiastic teacher with scientific attitudes and ability to use the problem-solving method herself. She does not need to know all of the answers, but she should have enough ingenuity and enthusiasm to help children find their own answers.

So many helps in the form of science readers and stories are appearing now that a word might be said for them. We no longer expect children to learn to read in a reading class and then be able to read with understanding in all of his other subjects. Informational reading in science is a skill in itself. Children have to learn to read science and to interpret it. Through the third grade, they are so busy learning to read that any reading to learn should be very, very simple. To gain information from their reading, it should be so easy to read that there is no mechanical difficulty. Frequently the concepts in the book are incomplete or vague. The teacher must anticipate these difficulties and prepare the children for them. In so far as possible, experience should precede the reading to make it meaningful. Then, at

least, the children will have more accurate concepts of the words they read.

Science well taught contributes to the development of the child by helping him to become better adjusted to his environment. By removing many unnecessary fears, science helps free the child from one cause of emotional instability. By teaching him to solve problems, it helps him to meet and solve life problems. By acquainting him with physical and biological laws, it helps give him a sense of security. By awakening an interest in science, it provides many worth-while hobbies that may help occupy leisure time. The person who has the opportunity to help children discover these things is often privileged to participate in real creative teaching.

WEATHER FORECASTING IN THE SUMMER CAMP

LOU WILLIAMS

Meteorology has been a part of school science courses for quite a few years, but perhaps it has reached its greatest popularity in the summer camp. Camping, sometimes said to be "America's contribution to education," has borrowed many things from the school, and has adapted them for its use. Perhaps the school may be interested in seeing how one of these borrowed projects has fared. The author, as nature counselor at Camp Long Tree, Three Rivers, Michigan, and later at Camp Andree, Briarcliff Manor, New York, had the opportunity to lead groups of children (children of from ten to fifteen years of age at Camp Lone Tree, and of from fourteen to seventeen at Camp Andree) in the study and practice of weather forecasting.

Our interest began with the tale of Benjamin Franklin, who, in 1747, arranged with his brother in Boston to make observations of an eclipse of the moon while he took simultaneous observations in Philadelphia. Shortly before the eclipse was to occur, a strong, northeast wind set in at Philadelphia, bringing with it clouds and rain, so that Franklin could not make his observations. Since the wind was from the northeast, he supposed that his brother also had been unable to see the eclipse. Great was his surprise when, several days later, he received the record of his brother's observations and the news that a heavy storm had begun there the morning after the eclipse. From further data connected with this storm, and from other observations as well, Franklin came to the conclusion that a storm is a moving formation, and that, although the winds which precede it usually blow from the east or northeast, its motion in our latitudes is from the west. As soon as the fact that a storm is a moving formation was fully recognized, the desire arose to keep track of storms and to herald their coming, and the modern science of meteorology began to develop.

We found from this story of Franklin that we must base our forecasting on the movement of storms from west to east. Here we first felt the need to discover why our weather varies; we needed to know why it varies before we could discover how to foretell its variations. We learned that each storm formation consists of air in a whirl. One type of formation, consisting of great spirally in-blowing winds, is known as a "low." Near the center of the counterclockwise whirl the warmed air rises, gives up its moisture in the form of clouds, and as a consequence rain usually falls. This region of rising air may be several hundred, or even a few thousand, miles in diameter. It moves daily from west to east, impelled by the

westerlies, sometimes bringing rain (or snow) with it. But air cannot forever rise; it must eventually fall again, settling as cold, dry air beyond the margins of the low. The settling cold air also whirls, but in a direction contrary to that of the low. This falling air makes up what is known as a "high." Fair weather prevails in the area covered by it on its eastward path.

As soon as we had learned about this procession of lows and highs moving west to east over our latitudes, we had found out why we have weather instead of climate. Our next task seemed to be to discover what sort of weather was present west of us, and to assume that this weather would be ours next. We subscribed to the Daily Weather Maps issued by the United States Government [1] and at first forecasted only by noting the areas on the map where rain and clouds prevailed. Such an area we figured to be at the center of a low. We knew that a storm formation moved from west to east at the rate of about five hundred miles per day; therefore we made attempts to forecast when the rain would reach us.

Our predictions were not very accurate as to time, and so we began to want to learn more about the map. The idea of temperature was a very familiar one to all of us. We learned the correct way to take the temperature, and announced our results to the rest of the camp along with our first uncertain weather predictions [2] At the same time, we began to notice the fine red lines drawn over the surface of the map. These lines are "isotherms," or lines of equal temperature. Knowing that the east side of a low is characterized by southerly winds, we were not surprised to find that the thermometer tends to rise as a low approaches. We added this fact to the means at our command for forecasting the first coming of a low.

The most outstanding feature of the weather maps—the concentric series of black lines—we could not at first use in forecasting. However, it seemed reasonable to us that when air is falling its weight and pressure must be greater than when it is rising. Therefore, at the center of a high, the air pressure must be greatest. Around this region the pressure is less and less until the center of the next low is reached, where the pressure is so small that the air rises. Each heavy black line is drawn through areas of equal air pressure, and is called an "isobar." Series of concentric isobars outline the highs and lows. Lining up the weather maps received during the previous week, we watched the highs and lows move from west to east across the country.

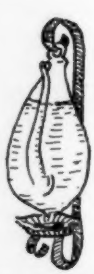
We soon learned, however, that highs and lows do not always move straight across the country in unbroken procession, but sometimes move diagonally, and sometimes get stalled for days. We realized that from the map alone we could not predict where the highs and lows were going to be, and that we needed to learn to distinguish between them from surrounding atmospheric conditions. For one thing, we decided that we must learn to tell

[1] Issued daily except Sundays and holidays for twenty cents a month, or $2.40 per year. Apply to nearest forecast center of the United States Weather Bureau (Washington, D. C., Chicago, New Orleans, Denver, and San Francisco), and pay by money order drawn to the Superintendent of Documents.

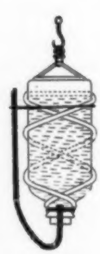
A booklet, *Daily Weather Map with Explanations,* may be ordered from the Superintendent of Documents, Washington, D. C., for five cents (no stamps accepted).

[2] A good thermometer shows very nearly the exact temperature of the air if it is exposed to the wind and at the same time fully shaded and well removed from all overly heated or overly cooled objects. The United States Weather Bureau places its thermometers in ventilated shelters in order to surround them with these necessary conditions. Old wooden window shutters serve well for the sides of such a shelter. Another way of observing air temperature accurately is to swing the thermometer vigorously so as to bring so much air in contact with the bulb that the effect of direct heating by surrounding objects is reduced to a minimum. An open space should be chosen in order to avoid obtaining temperatures of warm or cold pockets of air.

whether the air pressure was increasing or was lessening; that is, whether we were entering or leaving a high or a low. But differences in air pressure cannot be felt as can differences in temperature—hence the barometer. We began with the clipper-ship type, which appealed to us because of the service it has seen in old sailing vessels. This type of barometer—a simple, bottle-like device sealed at top and bottom, filled with water, and having a long spout —can be purchased at most department or variety stores for a little over a dollar. It is easy to understand how the heavier air pressure characteristic of a high can force the water back in the spout, leaving the opening dry, and forcing the water level in the bottle to rise slightly: thus the term "rising barometer" for the condition which foretells fair weather. However, when the pressure of the air resting on the spout decreases, as with the coming of a low, the air above the water in the bottle expands to reach the same density as the outside air and forces water out of the spout opening. When this happens the



Commercial Clipper Ship Barometer



Homemade Clipper Ship Barometer

From *Weather* by Lou Williams, Girl Scouts, Inc., 1937.

water level in the bottle will fall, so we say that "the barometer is falling." A falling barometer is frequently a sign of coming wet weather.

A clipper-ship type of barometer can be made for a few cents. Take an empty bottle that will hold about a pint of liquid. Bore a hole through a cork which fits the bottle tightly. Through the hole insert quarter-inch rubber or glass tubing, as in the illustration. Fill the bottle with water to within one or two inches of the top, and suspend the bottle by means of a raffia or string network.

After becoming familiar with this simple type of barometer, the campers could understand the mercury barometer easily. We learned that the numbers appearing on the isobars of the weather map indicated the number of inches of mercury standing in the barometer. Our second summer we were given an aneroid barometer, which enabled us to record more sensitive changes of pressure than was possible with the clipper-ship type, and to take numerical readings.

The campers were very much interested to learn that various types of clouds characterize the various parts of a low and of a high. Going out with dark glasses so that we could look at the sky more intently, we learned to identify clouds by comparison with the types pictured on the chart "Cloud Forms." [1] Then, by consulting some of the books which had been added to our weather library, we learned the particular place in a high or a low that each type of cloud characteristically occupies, and therefore the sort of weather to which each points.

Some of our weather-bureau members began to consult the "Wind-Barometer Table" [2] so that by combining wind direction and velocity [3] with the barometer reading, we could orient ourselves in respect to highs and lows and forecast even

[1] Superintendent of Documents, Washington, D. C. Price five cents. The August, 1935, issue of *National Geographic Magazine* contains many cloud pictures in connection with the article "Toilers of the Sky" by Kerbey McFall.

[2] Available from the Superintendent of Documents, Washington, D. C. Price five cents.

[3] The Beaufort Scale of Wind Force, reprinted in most weather books, shows how to determine wind velocity by noting the wind's effect on surrounding objects such as smoke, leaves, and twigs.

when we were cut off from the weather maps. Many of the three-or four-day canoe trips did not begin until the camp weather bureau could give assurance that they did not expect high winds or a severe storm. Members of the camp weather bureaus who went along on the trip were consulted when choice was being made between indoor and outdoor spots to spread the blanket rolls for the night. Overnight hikes were often postponed until the weather bureau forecasted a clear, starry night. When the members of the pioneer camping group dyed ponchos, they waited until the weather bureau could forecast clear weather and a good drying wind.

It was at about this stage that various charts began to appear in our camp "weather-bureau headquarters." These were slipped in among our other equipment by the campers who made them, and who usually announced their presence by inquiring if we'd "noticed anything different." One such exhibit included kodak pictures of cloud types with pertinent data concerning each. A very useful one showed the characteristic barometric and temperature structure of a high and of a low, with the winds and clouds characteristic of each part. To find our most trustworthy rain cloud one observer kept a record of how many times rain followed, within twenty-four hours, each type of cloud. Together with the barometers, the week's string of weather maps, thermometer, and the daily weather log, these charts formed the nucleus of our weather bureau.

The real fun came with forecasting. The campers who were interested met an hour each day during some of the two-week periods, gradually learning more and more of the principles of forecasting. At the end of each hour they made a forecast, basing it on the factors they had learned up to that time. However, many of the campers who stayed for a second session wished to continue forecasting. Even when the class was in session we sometimes wished to make a second daily forecast. During some two-week periods there was no place in the camp program for a regular class. To cover such situations we introduced the subject to all those interested, in a half-hour talk, and then carried on the actual forecasting each day with all those who wished to participate, meeting at a central spot for fifteen minutes before breakfast, and for fifteen minutes before supper. At each session we learned more about forecasting. As time went on, the leader tried to become a less and less important person as far as making the forecast went. Sometimes she failed to show up at all, and was pleased to learn that a forecast was made on time, albeit with a good deal of healthy argument! We usually kept a daily weather log, like that shown below, on which the observed map readings, barometer, wind direction and velocity, clouds, etc., were recorded, together with the forecast to which they appeared to lead. In such a chart, an important column is that headed "As It Was," where a record is made the next day as to how the forecast came out. If a mistake is made we look over the evidence on the chart to see what led us astray. A "Mistake Chart" to keep a record of erroneous forecasts and the factor to which the mistake may be attributed will help to show what factors are most trustworthy. It will also reveal peculiar weather quirks which may be present in the area, for in diagnosis a "knowledge of the patient" is important.

As time went on, we began to pick up more and more knowledge that helped in forecasting. Some of this knowledge we acquired because we needed it to make a difficult forecast, some of the questions were raised by our observations, and some of the data were found by campers who had become interested in a certain phase of the subject. We learned something about how clouds manage to stay up in the sky, how raindrops are formed, how

DAILY WEATHER LOG

Date	Hour	Wind Direction and Velocity	Clouds	Barometer	Map	Temperature	Remarks	Forecast	"As It Was"
Tuesday, Aug. 18	8 A.M.	NW 4 m.p.h.	Sky clear	Rising	In high	82°	Dew heavy	Fair: Not much change in temperature	
	6 P.M.	E 4 m.p.h.	Cirrus	Falling slightly	Small low due tomorrow night	86°		Continued fair tonight and tomorrow. Probably followed by showers Wednesday evening. Slightly warmer Wednesday	(Wednesday, 8 A. M.) True so far. But not warmer yet
Wednesday, Aug. 19	8 A.M.	SW Strong	Stratus	Falling	Low's path to us seems uninterrupted	83°	No dew on grass	Slight possibility of rain tonight. Cooler tomorrow	
	6:30 P.M.	S 5 m.p.h.	Stratus	Falling		87°		Rain late tonight or early Thursday. Clear and slightly cooler tomorrow	(Thursday, 8 A. M.) Rained last night. Clear and cool today

the beautiful crystals of snowflakes are built up, what conditions cause thunderstorms, what thunder and lightning are, how to forecast a thunderstorm by means of the dew-point test,[1] what sorts of lightning are dangerous, how to be safe in a thunderstorm, how to take pictures of clouds and lightning, how to predict the weather following a thunderstorm. We studied the origin of weather proverbs, and learned how to sift the true from the false. We made a weather vane from an orange crate and a broomstick.[2] Sometimes we merely announced our forecast to the rest of the camp; sometimes we used the flag system. Our flags measured 12 inches by 12 inches; the white one meant fair weather, the blue one rain or snow. A black pennant above the square added to the forecast "and warmer"; the black pennant below the square added "and cooler." We studied the history of the United States Weather Bureau and how it operates.[3] We collected samples of the observation messages in code which are sent in to a forecast center from the various observation posts—such cryptic messages as "Davenport: Amuck subagent fulgors geometry"; "Minneapolis: Agony eachs gaging ginnaty sealing." We discovered that there are unsolved problems of the weather: long-range forecasting, for example, and the autumn coloring of leaves. We also discussed solutions that have been suggested for these puzzles.

It seemed to a rather prejudiced observer that to campers who had learned the whys and ways of the weather, fear of a thunderstorm gave way to understanding of it, interest in it, and a wise prudence; that to campers who themselves had forecasted a stiff wind, the disappointment in postponing a canoe trip was lessened; and that for all, the joy of living outdoors was heightened through an increased awareness of this all-pervading background of our lives—the phenomena that make up our weather.

[1] C. F. Brooks. *Why the Weather.* New York: Harcourt, Brace and Co., 1924. $2.50.

[2] A. F. Williams. *Everyone's Book of the Weather.* New York: Macmillan Company, 1922. $1.00; *or* Gayle Pickwell, *Weather.* Los Angeles: Hugh F. Newman, 1937. $3.00.

[3] The work of the United States Weather Bureau is described in a pamphlet, *The Weather Bureau,* available from the Superintendent of Documents, Washington, D. C. Price five cents.

SOME NECESSARY CONSIDERATIONS IN CONSTRUCTING A CURRICULUM IN SCIENCE FOR THE ELEMENTARY SCHOOL

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Since the school curriculum is concerned with the growth and development of human beings, it must be subjected to continued change. Such a viewpoint makes constant revision necessary in the light of the growing experiences of those who work with the curriculum. Just as there can be no static periods during developments in the biological world, there can be no static interludes in the educative processes of constantly changing individuals.

The purpose of this article is to raise a number of questions, and outline a set of procedures for either constructing a curriculum in science for the elementary school, or for revising the existing program. No attempt is made to answer these questions, for that would only result in the "cook-book formula" type of curriculum which has met with little success in the light of modern requirements of an educational program. The answers are to

be found only among unified faculty groups of individual schools working together to achieve a common purpose. The basic assumption here is that each school is a unique entity and therefore should have its own curriculum adapted, in so far as possible, to the needs of its own personnel.

I

Constructing a curriculum is largely a matter of developing a philosophy of education by the persons who are to use the curriculum. This is the first consideration, for anything else that is done will be wasted effort in the light of a growing philosophy. The development of an entirely new outlook upon education will result for some teachers, while for others it may result only in the modification of present beliefs. In any event, however, there must be enough common agreement among the members of a school faculty in regard to educational philosophy to give unity of purpose. Of course, there will probably never be 100-per-cent agreement, which is as it should be.

The philosophy underlying an educational program, then, determines the objectives and provides the setting. The rest of the process is a matter of fitting the structure of the program into the setting in such a way that it will function smoothly and efficiently with the greatest benefit to the majority of pupils. For example, it does not matter so much how the objectives are stated as long as they are the best the group can formulate and their implications are clearly understood. The objectives of most courses of study seem splendid upon examination, but too often the teaching practices are so inconsistent with the objectives as to render them useless as guides.

Attention should be called to the fact that the procedures to be undertaken in developing a science program for the elementary school can be applied to the entire curriculum or to the so-called "subject-matter fields." Again, this is as it should be, for science does not exist for the sake of science, nor any other subject for its own sake. Subject matter exists for the purpose of implementing the child's experiences. Therefore, the philosophy in regard to the way these experiences are to be woven into the individual's total experiences should be common to all fields.

It might be well to raise the question as to who shall help with curriculum planning. Certainly the principal of the school or school system and the teachers should have the major part, for they are the users. Supervisors, subject-matter specialists, and curriculum specialists should be called upon to aid in evolving the philosophy and in helping check the accuracy of content. But they should not be left with the major part of the work on their hands, as is often the case, for then an "imposed-from-above" attitude is almost certain to arise on the part of the teachers. Certainly parents, or representative groups of them, should participate in curriculum-study groups. Antagonism on their part, arising from a lack of understanding of what schools are trying to accomplish, can often be avoided by such participation.

Children's reactions to experimental materials give them an indirect voice in the planning. Certainly they are to be given the major consideration, for the curriculum is being developed for them, but recent interest studies show that children tend to be interested in whatever the teacher is interested in. Thus, so-called "children's interests" are not a criteria for curriculum-making. Rather should their reactions to different types of experimental situations with varied kinds of materials provide them with a voice in curriculum construction.

II

One of the first practical considerations that is met in curriculum construction or revision is the basic organization that is to be used. The ideal situation would be freedom to use any kind of organization that seems most suited to the group for

which it is planned. However, the influence of the present type of organization must be taken into consideration, and the change from one kind to another must be made gradually. For example, a sudden change from a completely formal to an informal program would most likely prove disastrous. Neither the teachers nor the pupils would be prepared to meet the new situation.

Curriculum workers must ask themselves these questions: What is the basic organization now used throughout the school for all subjects? Is it satisfactory? Can we change it? What direction do we want these changes to take?

With the matter of organization in mind, the first question that arises is: Who shall do the science teaching? Is it to be done by the classroom teacher, by a specialist, or by some other plan? There is no single answer, for science is being taught very effectively in many schools by each of these different plans. However, the consensus of opinion seems to be that the teaching should be done by the classroom teacher with help from the specialist whenever it is needed.

An examination of courses of study over the country at large shows that one of the following types of basic organizations is generally used. Curriculum workers may well ask themselves, "What is the relation between the educational philosophy which we hold and the type of organization we use?"

1. *The incidental method* is one in which science is not given any particular organization. It is brought into the teaching of other subjects according to the teacher's judgment. It is not the purpose of this outline to evaluate or discuss the relative merits of different types of organization, for much good teaching is being done under the several methods that are presented here. But it should be pointed out that in such a method as this, the results are as apt to be like the name of the method. Also, teachers who are not well prepared in science have too little incentive to grow in science preparation and teaching under this type of organization.
2. *The period-by-period method* implies that the organization of the entire school is by subjects. Teachers treat each subject as a separate entity, usually following the organization of the textbook.
3. *The individual-unit method* consists of separate bodies of material from each of the different fields—science, social studies, etc. These are organized into teaching blocks of related materials that may show sequence from one unit to the other. Little claim is made for units paralleling each other, and separate objectives are usually selected from the course of study for each unit.
4. *Correlated units from several related fields* consist of materials from the physical phases of geography, from health, and from science. These materials are selected with regard to common principles, and with regard to relationships between these subjects. Material from one field is used interchangeably to enrich the development of another field. Literature, art, mathematics, and social studies contribute, but each grouping of fields retains its identity in the curriculum. For example, the language-arts group, composed of literature, reading, spelling, and grammar, contributes to the development of the science group; but language arts still has its basic place-and-time allotment. Such a curriculum usually recognizes these groupings or some combinations of them: natural sciences, social studies, language arts, fine and industrial arts, and mathematics.
5. The core curriculum places its emphasis upon one subject field with other fields contributing what they

can in the way of related materials. This organization holds a certain body of material as more essential to the growth of the individual than that of other subject fields. It attempts to show as much relationship as possible between the core and other fields and yet retain a certain amount of identity of the different fields. Some educators classify the core curriculum as an intermediate or transition stage between the older type of formal, set-in-advance curriculum and the more informal types which follow.

Each type of organization has its adherents who believe it to be superior to the others, and who are ready to defend it as "the way." Diversity of opinion and practice is desirable in education as in other professions. Diversity in curriculum organization may seem closely akin to chaos, but only through much discussion and experimentation is progress made. It should be pointed out in passing that all methods of curriculum organization at all times have had their strong and their weak points. Any group undertaking construction on reorganization of a curriculum will do well to recognize this and retain what has proved its worth from the old and select and use the good points of the new.

6. The fused or "integrated" type of curriculum is based upon major social processes which are functional in all group living. Consequently no subject-matter fields are recognized, and material from all fields may be used so long as it contributes to the understanding of the social processes that are set up as objectives. Attention should be called to the fact that the preceding types of curricula may also be based upon processes which apply to group living, but the fused curriculum makes the understanding of social objectives its major emphasis. While this organization undoubtedly gives the individual teacher more freedom, it also places more responsibility upon him in knowing how to provide worth-while experiences for the children.

   Curricula of this sort are attracting much attention and seem to have decided possibilities for meeting some of the needs that are manifested by the widespread dissatisfaction with more formal types of organization. Curriculum workers and other interested persons should investigate the possibilities and limitations of the fused curriculum thoroughly before attempting it, for undoubtedly much of the difficulty that has been met with in its use was not due to the weaknesses of this kind of curriculum. They were due to the unfamiliarity of the teachers themselves with the philosophy and with the way in which it should be presented.

7. Another kind of organization that has appeared sporadically in science-teaching in the upper elementary and junior school is the search-discovery method. It might be termed the "left wing" of the curriculum group. It proposes that children shall work either individually or in small groups on any particular topics of science that happen to claim their attention. Of course, guidance in selecting these topics is given by the teacher, who then stands by to give aid whenever necessary and to see that the child sticks to the topic until he has made as thorough an investigation as time, the child's ability, and other conditions permit. The search-discovery method undoubtedly has something to offer as a type of curriculum organization in upper-grade science, but its limitations are so great that careful research should be done before it is given serious consideration.

III

When the philosophy and organization which is agreeable to the majority of teachers in a school have been selected, the problem of what form the written part of the curriculum shall take must be decided. Again, the answer rests with the group using a particular curriculum, but a few suggestions may be of help here. Certainly the curriculum should be very flexible to permit as much change as seems necessary. Even the written form the course of study takes, whether printed or mimeographed, should allow for easy modification from time to time. One of the dangers of printed courses of study is that when they have been used for a considerable length of time they may come to be regarded as "the way" and thus defeat the very purpose for which they were planned. The wording and organization should be such that curricula can be easily understood by those examining them. How many workers must have had the experience of seeing their courses of study misinterpreted and misused by others because of lack of clarity and simplicity of expression. Examining such a curriculum leaves the uninitiated with a "just-what-were-they-driving-at?" feeling.

IV

Another important consideration is: Will it be possible for new teachers who come into the system to interpret the curriculum and fit into the school system in a profitable manner? New teachers will not have had an opportunity of helping with the planning, and even though they were excellent teachers in another system, they may not prove so in a new situation unless provision is made for helping them make adjustments.

V

What classroom space and other physical facilities such as storage space, display cases, bulletin boards, and gas and electrical connections are available? This problem is of vital concern in rapidly growing schools that have overcrowded classes. A check-up of these should be made to avoid idealistic planning which has no means of satisfying its requirements. For example, it has been estimated that less than 20 per cent of the schools teaching science in the elementary grades have room for caring for constructional and other activities around which the science program may center. Lack of ideal facilities should not prove a deciding factor in the type of organization that is to be effected, for many clever teachers are doing splendid work with practically no equipment. However, a survey of physical facilities is of decided importance in establishing a smoothly operating science program.

VI

What possibilities for growth in subject-matter backgrounds and techniques are available for use with the evolving curriculum? The increasing attendance of elementary teachers in science classes in night schools and in summer schools attests to the needs that are being awakened by recent curriculum development in science. Curriculum specialists are the engineers who help teachers plan the basic structure of the curriculum, but the teachers themselves are the users. Certainly possibilities for professional growth of teachers should be considered in the early stages of program-planning.

VII

How shall the results of the curriculum in science for the elementary school be evaluated? This is one of the questions that will probably cause the gravest concern on the part of the curriculum workers because of the lack of adequate tools of evaluation. The answer must be made in terms of the philosophy that underlies the curriculum. Lack of space prohibits a discussion of current practices and trends in checking the results of instruction ac-

cording to recent curriculum developments. But certainly no group of educators can afford to undertake the construction of a curriculum without provision for the study of evaluation of the outcomes of their teaching, and for experimentation in an effort to find new and more effective ways of making evaluations.

By way of summary, the following points were presented as being worthy of major consideration in constructing a curriculum in science for the elementary school.

1. Developing a philosophy common enough to give unity to the program by those who are to help construct and work with the curriculum.
2. Determining, in the light of the accepted philosophy, the organization of the curriculum.
3. Determining a clear, flexible, and usable form for the written part of the curriculum.
4. Planning the curriculum so that new teachers may fit into it with profit to to the school and to themselves.
5. Surveying physical conditions of the school to plan for the wisest use of materials and space.
6. Considering possibilities for continued growth in subject-matter backgrounds and teaching-techniques on the part of teachers.
7. Considering how the outcomes of the science curriculum may best be evaluated.

THE CURRICULUM FOR THE ELEMENTARY SCHOOL

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"Of the making of curricula there is no end."

Why should this be so? Why is the curriculum so important that there is a constant reworking and rearranging of its materials? Because it lies at the foundation of any educational activity. Its character is determined by the aims or objectives of the teacher. It is a definite series of studies or activities to be undertaken. Much could be said concerning the development of boys and girls into men and women with a well-rounded viewpoint—persons at home in many fields of human endeavor. Here, however, we are concerned with only one of those fields of racial activity and inheritance—Science.

In the last hundred years science has developed rapidly and has come to exercise an incredible and probably an unmeasurable influence upon conditions of human living as well as upon the character, growth, and existence of animals and plants. In any intelligently constructed program of studies, a good measure of science instruction must be included. In view of the need of our times there should be no neglect of scientific discoveries and the type of thinking and procedure that made them possible.

For a long time now there has been a tendency to "teach subjects"—to regard each subject as an independent unit rather than as one part in a sequence of studies designed to contribute to the development of a well-informed individual with a broad, intelligent outlook on life. Such an aim will never be reached so long as we insist on teaching subjects and building up departments in the sense that, through pressure, insistence, and possibly devious ways, more and more of some special area of subject matter is included. The question is not, "How much work in this or that

can I get included?" but "What will best contribute to the development of the child? How can he be helped to develop into an intelligent layman?"

An educated person knows something of the culture and problems of the age in which he lives. That this may be true, he must know something of the conditions from which the culture and problems arose. His teachers will need to call upon all sources of human endeavor and activity. One of those great streams of racial activity and inheritance is science.

As soon as man, in the early days of the race, acquired items of knowledge from experience, he instinctively classified them as related to certain objects and explaining certain phenomena. This process of organizing knowledge in terms of relationships between facts and principles has continued apace until one stands amazed before the ever-increasing complexities of logically organized knowledge. To learn or to use it all is impossible.

Selection must be made, and this selection is the crux of the whole matter. In what terms shall selection be made? How shall the selected items be used? To what end is the selection made?

A partial answer to the last question has been made. It is desired to accomplish certain things for the children of our schools. We have no desire to make scientists of the children. We do desire to make them intelligent citizens in this modern world; we do desire to make them informed concerning their environment, both the natural one and the acquired one; we also desire to give them leisure-time activities; above all, we desire to give them the tools for attacking all those problems which await their solution.

Turning now to the second question. In what terms shall the selection be made? In terms of functional use for the children plus those things from the historical past of our race which time and experience have shown to be most worth while. Does that seem such a big order? There has been a good deal of work done in this field of selection. The Thirty-first Yearbook [1] lists thirty-eight principles or generalizations as valuable for guidance in the selection of specific objectives of science teaching. Craig [2] in his study lists about fifty. Croxton [3] gives twenty-four. The writer [4] in her study dealt with nineteen specific science generalizations and six allied generalizations relating to the method of science which should be the residuum of science teaching. All the studies cited deal to a greater or less degree with the science curriculum as employed in the training of elementary-grade teachers.

The new syllabus dealing with the organization of elementary-school science in the grade schools of New York state lists six content areas—three biological and three physical. Within these areas, there are smaller specific generalizations for each grade.

In this instruction, both for future teachers and grade children, there should be much emphasis on the method of science. Scientific thinking as it applies to all problems should be taught. Of course, it is understood that scientific thinking is not the particular possession of science, but in this area the peculiar method of science has been developed. From it have followed scientific methods of attack on problems in all fields of endeavor.

The great science investigators have shown us how, by the application of this

[1] National Society for the Study of Education. *Thirty-first Yearbook*, Part I. "A Program for Teaching Science." Bloomington, Illinois: Public School Publishing Company, 1932.

[2] G. S. Craig. *Certain Techniques Used in Developing a Course of Study in Science.* Contributions to Education, No. 397. New York: Teachers College, Columbia University, 1930.

[3] W. C. Croxton. *Science in the Elementary School.* New York: McGraw-Hill Book Company, 1937.

[4] A. M. Gemmill. *Science Education for Elementary Classroom Teachers.* Contributions to Education, No. 715. New York: Teachers College, Columbia University, 1937.

method, they have achieved their results. Indeed, it is their method which has become our scientific method. The writer knows of no better material for use in stressing intellectual integrity and suspended judgment than the lives and accomplishments of the great scientists. It is useful, too, to indicate their failures and show that their mistaken judgments and failures were due to violations of scientific method.

Too often in our science teaching we have destroyed the child's native curiosity concerning the world and himself as a part of the world. By deadly routine and set practices in the classroom many a lovely thing has been killed. It is our compelling duty as teachers administering the curriculum to so manage that the natural curiosity of the child shall become a lasting compulsion toward intellectual activity. His natural childish questions of What? How? Why? should always remain, but with the passing years the answers should become fuller, more mature, and more satisfying.

Someone has said that the scientific method is a socially necessary function if we are to have citizens capable of successfully carrying on democratic institutions. This puts a heavy burden on the teacher of science, be the teaching done in the grades, in the secondary school, or in the college. The teacher himself must be familiar with the method of science and exemplify it in his daily activities if he is to teach it to others.

As the great principles of science are studied, the child must come to feel the adventure of civilization itself—how man has achieved a conquest of natural forces and materials. This conquest was only possible through the application of scientific principles to the problems of the environment. Here probably modern achievements in the submarine and flying boat, in radio and television, will function as the subject matter.

In order to have an individual perspective so as to understand such material fully, there needs to be some understanding of the scientific world picture as it has been slowly built up through the ages. It will run the whole gamut from electrons to galaxies. Here the teacher must do for science as a whole what Lemon[1] did for physics in his *From Galileo to Cosmic Rays:* he must survey the field in its entirety.

Of course, too, the children need and should receive an understanding of the essential biological principles basic to the maintenance of individual and community health. They should be taught the personal and social obligation of living according to the new morality so that the integrity and effectiveness of social relationships may be increased. The children should gain an acquaintance with both plant and animal life. They should see adaptations and inter-relationships, adjustments to seasonal change, and continuity of life. A general acquaintance with the simpler aspects of geology and astronomy should be given the children. To sum it all up: there should be available for the children of the grade schools knowledge concerning the world of living things together with a consideration of the environment in which those living things find themselves and the control which man is increasingly exercising over his environment; knowledge should be available concerning the earth's origin and history and the larger universe of which the earth is a part.

To go back to the second question: how shall the selected items be used? The selection is made from the great body of tested scientific principles. It must be clearly understood that the science generalization or principle is but a short statement or summation of a long experience with the phenomena of the environment. It is an epitome of racial science

[1] H. B. Lemon, *From Galileo to Cosmic Rays.* Chicago: University of Chicago Press, 1934.

experience. To be useful in a teaching situation it must be broken down into the original experiences from which it was formed. To use Dewey's term, it must be "psychologized," that is, broken down so that the science experiences from which it came will fall within the understanding and experience of a child.

From the learner's standpoint, experiences which originally led to the generalization must be had, and from these experiences, ideas or essential meanings will be developed. The more experiences available, the clearer and more understandable the idea.

In this fashion the original racial science experiences become for a second time the chief factors in a learning situation. Demonstrations, experiments, field trips, diversified reading, home experiments of a simple nature, should be the prevailing techniques. Along with these activities should go free discussion and the reporting of anything germane to the work in hand. The discussion and reporting can take place either in the class group or in the smaller committee groups.

The understanding of a science generalization is not arrived at easily or soon. Teaching may be consciously directed toward an understanding of a generalization, but it may be years before the generalization will be realized in its entirety. Understanding may be begun in the grade school and but partially accomplished in the graduate school. Not all science can be taught in all grades of the elementary school. As the generalizations of science are broken down into their basic meanings, it will be seen that selection of material of varying degrees of difficulty suitable for the various grades can be made.

The same materials cannot be used in every teaching situation. The experience or knowledge that the child already possesses must determine what activities and accompanying subject matter the teacher will select in the gradual upbuilding of the desired generalization. Upon the wisdom with which the generalizations are chosen and the skill with which they are developed will rest the success of this method of instruction.

With the increasing interest in a program of science studies for the elementary school a new service may be accruing to science. Science has never before been asked for values. Her only recognized function has been to suggest or invent economic devices so that production might be more successful. Somewhere John Dewey says, "If ever we are to be governed by intelligence, not by things and words, science must have something to say about what we do and not merely how we may do it most easily and economically."

A NEGLECTED FACTOR IN THE TEACHING OF ELEMENTARY SCIENCE

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Careful observation of teaching in the field of elementary science reveals that one of the weakest points in instructional technique is our treatment of the hypotheses of children. Student teachers are often ignorant of the nature of hypothesis. Inexperienced teachers are often unable to identify such. Experienced teachers forget at times the importance and method of its proper control and direction. It seems, therefore, that discussion of the nature, possibilities, control, and direction of the hypothesis as it is met in the classroom will be helpful to teachers of elementary science.

NATURE OF HYPOTHESIS IN ELEMENTARY SCIENCE

The hypothesis may be variously described. Popularly considered, it is a guess. It is a supposition. It is of the nature of a simile. It is "as if"; that is to say, something that is not known is "as if" or "like" something that is known. Common to these various descriptions is the concept that the hypothesis is a tentative solution—a solution that has not as yet been adequately tested relative to the particular questions and facts under consideration.

A second-grade class wonders how glaciers could have made lakes. Several children suggest that glaciers could "dig holes" which would become lakes. Others suggest that the glacier could transport rock and soil which would "make dams." Here are two guesses, suppositions, hypotheses, or tentative solutions. They are attempts to explain an unknown "as if" it were "like" something which is known. The method of lake formation by glaciers is unknown. Experiences with digging holes in the ground and with making ditches and dams are known. The unknown is explained in terms of the known. Lake formation by glaciers is explained "as if" it were done "like" the children dig holes or make dams.

A sixth-grade class observes a candle burning within a closed jar. Soon after the candle is lighted, the flame becomes less intense and then it "goes out." Why? Most of the children observe the droplets of water vapor on the inside of the jar, and several suggest that "water vapor puts out the flame." This is a hypothesis, and it is valid in so far as the laws of thought are concerned because it explains unknown phenomena in terms of known. The cause of the candle's ceasing to burn is unknown; prior experience with water and fire are known. The candle that was burning in the closed jar "goes out" because "water put out the fire."

It should be noted that, according to our initial definition, a good hypothesis may not be a correct one. Teachers are very sensitive to correct explanations. Our misguided eagerness for them is one of the primary causes of our poor teaching. But we may not be aware of the characteristics of a good hypothesis. What is a good hypothesis?

CRITERION OF GOOD HYPOTHESIS

One of the best criterions of a good hypothesis is adequacy in harmonizing two different facts or sets of facts. For example, when the operation of a medicine dropper is demonstrated to children, they frequently explain the action (hypothesize) by saying, "It is suction." According to

our criterion, this is not a good hypothesis because nothing is known or can be known about "suction." "Suction" does not present a fact or set of facts with which any facts observable in the operation of a medicine dropper can be harmonized.

When, however, children venture the explanation that the medicine dropper works as it does because, by pushing on the rubber, we make friction that "attracts the water up into the droppei," we have a more valid hypothesis even though it is far from correct. It is a more valid hypothesis because it presents for analogy with the observed facts in the operation of the dropper a set of facts derived from certain experiences with the attractive action of static electricity. The medicine dropper does work "as if" electricity were formed on the rubber. When children thus hypothesize, with some validity, the action of the dropper, there are two facts or sets of facts to harmonize, for rubber excited by friction does attract substances, and when the rubber of the dropper is manipulated water flows toward it.

In an earlier example it was stated that children hypothesized validly when they proposed an explanation of the extinguished candle flame in terms of water vapor. The hypothesis is valid because it presents for consideration definite facts for comparison with the facts observed in the extinguishing of the candle flame. It is valid (although the adequacy will be refuted by investigation) because "water does put out fire" and the candle "went out" just about when the water appeared on the sides of the jar.

SOURCE OF HYPOTHESIS

Prior experience is the source of hypothesis. Those data or phenomena under immediate consideration do not furnish the material for the hypothesis. In the course of lessons with plants children may inquire as to whether a white potato is a root or a stem. The suggestion will be made that it is a stem. (Both root and stem will be suggested, but the derivation and implication of only the latter hypothesis will now be considered.) What is the source of this hypothesis? It is prior experience. The children observe the potato and the "eyes" suggest buds. Buds grow on stems, and therefore "if" the "eyes" are buds the protato is a stem. The potato looks "as if" it were a stem. But if the children knew nothing whatever of buds or stems, the "eyes" of the potato, though observed very closely, could not suggest buds. The data at hand suggest the hypothesis, but the source is prior experience.

True learning is a spiral movement. Acquired experiences yield hypotheses, and the hypotheses give the opportunity and occasion for the acquisition of new experiences which can, in turn, be the source of new hypotheses. Facts, experiences, principles, and generalizations must never be regarded as final and fixed possessions. Learning must never become a closed circle.

ABSTRACTION NECESSARY FOR HYPOTHESIS

Abstraction is one of the most noteworthy psychological processes involved in the ability to hypothesize. The child must abstract from the complex of data under observation those figures that are pertinent to the background or prior experience, and from the complex of background experience there must be an abstraction of features pertinent to the data under observation. Without this process of abstraction, accumulation of immediate or background data is of little value.

When children by the aid of models explain the cause of summer and winter by advancing the hypothesis that the earth is nearer to the sun in summer than it is in the winter, they are abstracting certain data from the immediate experience. They are isolating for consideration the facts that *the earth revolves around the sun in an elliptical orbit, and the sun is nearer*

one end of this orbit. But this hypothesis is more than an abstraction from the immediate experience.

There is also an abstraction from prior experience. From more remote background experience concerning causes of temperature change, the children isolate the fact that *the nearer you get to hot things the hotter they feel.* Then by a synthesis of these two sets of abstracted data, they formulate the hypothesis that *the earth gets warmer in the summer because it is nearer to the sun.* Abstraction from prior experience was as necessary for this hypothesis as abstraction from immediate experience.

But how shall incorrect hypotheses, like that just discussed, be corrected? Formulation of a more correct hypothesis may be facilitated by direction and control of the process of abstraction. It is here that the teacher is especially needed. The teacher has an important, but not authoritative, part in the correction of hypotheses.

DIRECTION AND CONTROL OF HYPOTHESIS

Experiment is one of the most useful means of directing and controlling the process of abstraction in the formulation of hypothesis. The teacher facilitates abstraction by guiding activity so that (a) certain features of the data are more plainly indicated, (b) relevant data are multiplied, and (c) irrelevant data are diminished, concealed, or eliminated. One or more, and often all, of these methods may be employed in a particular classroom situation. Experiment used as direction and control of hypothesis is of great value for child-learning.

In the illustration just given of the hypothesis concerning the cause of summer and winter, the teacher might ask the children to especially note the position of the north pole of the globe that represents the earth as it is carried in its orbit about the light which represents the sun. Thus certain features of the data would be more plainly indicated. Abstraction of data significant for hypothesis would be facilitated by this direction of attention.

Or the teacher might ask the children to repeat several times the process of carrying the globe about the light with always the twenty-three-degree inclination of the axis and its constant direction. Thus certain features of the data would be emphasized by multiplication. Abstraction of data valuable for a productive hypothesis of the cause of summer and winter would be aided by such repetition.

Or the teacher might place the globe several times in the summer and winter position without taking it in an elliptical orbit about the light. Thus irrelevant data would be diminished, concealed, or eliminated. Distraction of attention from significant data would not be likely, even though there would be no direct emphasis of such. By not taking the globe in the orbit about the light, data relative to direction of motion, distances from the light, etc., would be eliminated temporarily from consideration.

OBSERVATION AND HYPOTHESIS

Observation and training of observation are sometimes ranked as important objectives for elementary science. But observation is an activity and must have significance for the child. When observation is directed by hypothesis, it is of high educational value.

For example, when children study leaves, they might be required to observe minutely the shape and condition of the margin, and the exercise might be quite extended, including drawings of the leaf and margin, making leaf prints, careful descriptions, etc. But these observational activities would be of great significance and educational value when used as a means for verification of hypothesis. Such a hypothesis might be one relative to questions of maximum light incidence for the leaf. Hypothesis gives pertinence to the facts

observed. It is the means by which accurate observation is best secured, and it may be functionally trained and developed through practice in formulation and verification of hypothesis. Observation should be justified and guided by the significant purpose of hypothesis.

SUMMARY

The instructional significance of children's hypotheses is not generally understood and appreciated. Because the hypothesis is a tentative solution or a guess, it is often incorrect. The teacher who is too intent upon correct answers may miss the values and possibilities of the incorrect ideas of children.

There are valid and invalid hypotheses, but a valid hypothesis need not be a correct one. Adequacy in harmonizing two facts or sets of facts is a good criterion of validity.

Prior experience is the source of hypothesis, but it is suggested by the data under immediate consideration.

True learning is a spiral movement involving experiences, facts, and hypotheses; and no fact, principle, or generalization must be regarded as ultimate and fixed.

Abstraction is very necessary for formulation of hypothesis, but the process must be directed and controlled. Experimentation is one of the best controls.

Observation is an activity which acquires meaning and value for the child when it is used for test and verification of hypothesis.

NEW BOOKS FOR YOUR SCIENCE LIBRARY

GLENN O. BLOUGH
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Teachers and supervisors of grade-school science are constantly finding need for supplementary materials in science. Frequently the need arises and there seems to be no appropriate source to suggest. To meet this need the following recent (1937–38) books of a supplementary nature have been annotated and listed. They have been selected from a large number of new books because they contain well-selected, accurate, interesting content, and because they fit definite needs as supplementary materials. Recent textbooks, work books, teachers' manuals, and examination books have not been included. A few of the newer books for the teacher have also been included.

BOOKS FOR THE TEACHER

CROXTON, U. C. *Science in the Elementary School.* New York: McGraw-Hill Book Company, Inc. $3.00.
Useful for presenting a background and a point of view in science-teaching and for suggesting activities on various units. The inexperienced teacher as well as the supervisor will find this book very useful in administering the grade-school program. Bibliography helpful.

FENTON, CARROLL LANE. *Our Amazing Earth.* New York: Doubleday, Doran and Company, Inc. $4.50.
An excellent source of information useful for the elementary teacher who needs a general background for teaching units on "The Changing Surface of the Earth," "Rocks and Minerals," "The Earth," "Fossils," and other related topics. Especially useful since it presents the material accurately but in a non-technical manner. Text material unusually interesting. Illustrated with diagrams and pictures.

FOX, LORENE. *Antarctic Icebreakers.* New York: Doubleday, Doran and Company, Inc. $2.50.
A complete story of Antarctic exploration from earliest times to present day. Foreword by Dr. L. M. Gould, second in command of the first Byrd Expedition. An absorbing story containing much valuable information as well as exciting incidents. Useful for social-studies background material as well as providing information useful in the study of the

science aspects of climatic conditions, explorations, and transportation.

HUDSPETH, JACK, and HUDSPETH, FRANCES H. *Handbook for Teachers of Elementary Science.* Austin: Steck Company. $0.50.
A handbook for the elementary teacher who needs help in the following: general methods in science, preservation of material, maintaining equaria and terraria, using microscopes, using visual aids, etc. Especially useful to the teacher with no science background.

HURLEY, RICHARD JAMES. *Key to the Out-of-Doors.* New York: H. W. Wilson Company. $2.50.
An extensive bibliography on the following topics in science: astronomy, meteorology, geology, plants, trees, insects, reptiles, amphibia, water life, birds, and mammals. Other sections of the book treat general materials, magazines, pictures and lantern slides, nature bibliographies and reference books, and addresses of film sources, book publishers, and pamphlet publishers. Bibliographies are briefly annotated; book prices are given. A very useful book for the teacher of science.

MILLER, DAVID F., and BLAYDES, GLENN W. *Methods and Materials for Teaching Biological Sciences.* New York: McGraw-Hill Book Company, Inc. $3.50.
Useful as a background in science education and very helpful to the grade-school teacher in preparing and using classroom materials. Treats such topics as collecting, keeping live material, and using the microscope, and suggests a large number of demonstrations and experiments with plants and animals.

WILLIAMS, S. H. *Our Living World.* New York: Macmillan Company. $3.60.
A general source book for a teacher who needs information about living things. Written as a basic text on nature study, field biology, and elementary ecology courses. Contains extensive reference lists on various topics Material is not so technical as to be meaningless to the teacher with little background but is sufficiently inclusive to be an excellent reference source.

BOOKS FOR CHILDREN

BAER, MARIAN E. *The Wonders of Water.* New York: Farrar and Rinehart, Inc. $1.50.
A useful reference. Clearly and interestingly written. Informative. A valuable addition to a library for elementary-science pupils. Not difficult to read. A good reference for the pupil who is interested in science but finds reading a difficult task.

BARTON, WILLIAM H., JR., and JOSEPH, JOSEPH MARION. *Starcraft.* New York: McGraw-Hill Book Company, Inc. $2.50.
Contains a detailed study of the stars and simple, clear directions for building instruments for making observations. Directions are given for making a cross-staff, a quadrant, an altazimuth, various sundials, and a simple reflecting telescope. It is not necessary for the pupil to construct these instruments to enjoy the content of the book, for much space is devoted to a general discussion of the stars and the solar system for the naked-eye observer. A very useful reference on astronomy.

BEATY, JOHN Y. *Trees.* Chicago: M. A. Donohue and Company. $1.50.
A book of unusual information about trees told in an interesting style. Includes material on how trees react to injuries, how various enemies affect trees, how trees grow and develop. The test is very effectively illustrated with photographs. A useful book for grades studying plants, conservation, effect of environment on living things, or inter-relations of living things.

BRONSON, WILFRID S. *The Wonder World of Ants.* New York: Harcourt, Brace and Company, Inc. $1.50.
An illustrated reference book on different kinds of ants.

CHAPMAN, WENDELL, and CHAPMAN, LUCILLE. *Beaver Pioneers.* Chicago: Charles Scribner's Sons. $2.00.
The story of two beavers, their mating, and the beginning of a colony. Illustrated with photographs. A good source book for pupils interested in the habits of animals and a fine supplementary source in the study of the habits of social animals.

EISEN, EDNA E. *Our Country from the Air.* New York: William Morrow and Company, Inc. $2.00.
An account of an imaginary journey over the United States. Illustrated with photographs. Useful as a geography reference. A trade edition of the volume published by Wheeler Publishing Company.

EMERSON, ALFRED E., and FISH, ELEANOR. *Termite City.* Chicago: Rand McNally and Company. $1.50.
Excellent reference material. Useful as source material for special reports on the study of insects or social-animal groups. Easily read and comprehended by pupils in later elementary grades.

FISHER, CLYDE. *Exploring the Heavens.* New York: Thomas Y. Crowell Company. $2.50.
An accurate reference, well illustrated and up to date. Can be used as a source for special reports and for pupils' individual research. Excellent for the pupil who wishes information in addition to that supplied by text and class discussion.

FROST, EDWIN B. *Let's Look at the Stars.* Chicago: Houghton Mifflin Company. $2.00.
An excellent reference book in astronomy. Can be read by good sixth-grade readers. Illustrations from photographs made at Yerkes Observatory.

HOLLAND, RUPERT S. *Big Bridges.* Philadelphia: Macrae Smith Company. $2.00.
An authentic account of the history of bridge-making. Includes the modern bridges and describes their constructions. Useful as a reference book in social studies as well as in science. Treats many phases of bridge-building—interesting to elementary-science pupils.

KEARNEY, PAUL W. *Strange Fishes and Their Strange Neighbors.* New York: Doubleday, Doran and Company. $1.25.
An excellent book for children who are interested in fish, strange and otherwise. Very useful as a reference for the pupil with a special interest and as a supplementary book if the class is studying water animals. Useful also before and after a visit to a public aquarium, since it tells interesting information about many of the animals often seen in such aquaria. Interestingly written, very well illustrated with photographs by the author.

KING, ELEANOR, and PESSELS, WILLMER. *Insect Allies and Insect People.* New York: Harper and Brothers. $1.25.
Two interestingly written books about common insects. They present material to show the value of a scientific study of insects and the methods involved in such a study. Useful as a source of information about specific insects and in acquainting the interested pupil with the scientific method. Can be read by fifth- and six-grade pupils. Well illustrated.

LYNDE, C. J. *Science Experiences with Home Equipment.* Scranton: International Textbook Company. $1.25.
Useful to teachers who have only a little apparatus to use in elementary science. Valuable in suggesting experiences in addition to the usual classroom experiments. Pupils will enjoy doing the experiments at home and reporting the results, or performing the experiments to supplement the class procedure.

MCINTIRE, ALTA. *Butterflies and Moths.* Chicago: Follett Publishing Company.
An easily read account of the life-histories and habits of common moths and butterflies. Good clear pictures, interesting text. Obtainable in inexpensive, paper-covered editions. One of a series of Picture-Story books. Other science titles are *Baby Animals, Creepers and Sliders,* and *Wild Animals at Home.*

MORGAN, ALFRED. *Things a Boy Can Do with Electricity.* Chicago: Charles Scribner's Sons. $2.00.
A practical book for the boy who is interested in electricity and who likes to experiment. The equipment suggested is inexpensive, the descriptions of the experiments are clear. Useful as a source of experiments to illustrate science principles and to supplement the experiments in textbooks and courses of study.

PETERSHAM, MAUD, and PETERSHAM, MISKA. *The Story Book of Oil.* Philadelphia: John C. Winston Company. $0.60.
Easily read, colorfully illustrated. Useful as leisuretime readers, as special-report sources, and for reading aloud to answer questions. One of a series which includes books on the subject of foods, earth's treasures, transportation, things we use.

PIGMAN, AUGUSTUS. *The Story of Water.* New York: D. Appleton-Century Company, Inc. $1.50.
The story of water and its importance to man and to cixilization down through the ages. Interesting discussion of the uses of water. Useful as a class reference or as reading material for the child with special interests.

PORTER, WALTER P., and HANSEN, EINAR A. *Fields and Fencerows.* Chicago: American Book Company. $0.84.
A book of interesting information about plants and animals. Useful as a reference source in the upper elementary grades. Will supplement many phases of animal and plant study by giving detailed information difficult to find elsewhere. Interestingly written. Illustrated.

PRICE, MARGARET EVANS. *Down Comes the Wilderness.* New York: Harper and Brothers. $1.75.
An interesting story of children's contact with wild animal life. Elementary pupils will enjoy the story and will find it instructive and absorbing. Useful in connection with conservation work and with any unit involving animal life.

SCHMIDT, KARL PATTERSON. *Our Friendly Animals and Whence They Came.* Chicago: M. A. Donohue and Company. $1.50.
A beautiful illustrated book about animal life, treating the development of various groups, *i.e.*, dogs, cattle, sheep, horses, etc. Pictures very useful in lower grades; text useful for reading in the upper grades. Many full-page colored pictures.

SMITH, NILA B., and TROXELL, ELEANOR. *A Look at the Weather.* New York: Silver, Burdett and Company.
Graded material in pamphlet form. Illustrated. Inexpensive. Useful for supplementary reading. Other titles include *Hop Hop Hop!, Come and See, Balloons and Airships,* etc.

WEBSTER, HANSON HART, and POLKINGHORNE, ADA R. *What the World Eats.* New York: Houghton Mifflin Company. $0.92.
An interesting story of how foods look when they are growing, how they are prepared for our use, and how they are sent to our stores. The contents consist of five sections: "Our Favorite Fruits," "Vegetables at Home and in Other Lands," "Cereals and Bread," "Foods We Get from Animals," and "Other Foods." Useful in connection with units on foods, the human body, and how plants grow.

Who's Who in the Zoo and Birds of the World. Prepared by the Staff of the Federal Writers' Project of the City of New York. Chicago: Albert Whitman Company. $1.75.
The zoo book contains much interesting information about more than a hundred animals. It deals with the habits of animals that are often seen in modern zoölogical parks. Children will enjoy the beautiful photographs, and older pupils will profit from reading the material before or after a visit to the zoo. Various zoölogical institutions of New York City have checked material for accuracy. The bird book is also beautifully illustrated and contains more than a hundred biographies of representative species of bird life. The book is useful to pupils of any grade interested in bird study. Early grades will find the photographs useful in learning about habits, environmental adaptations, etc., of birds, and the reading material will make the book very useful to later elementary grades.

WYLER, ROSE, and MCSPADDEN, W. W. *Electricity Comes to Us.* New York: Grosset and Dunlap.
An illustrated book giving interesting information on the subject of electricity. The text stresses the practical aspects of the subject. Useful for pupils of special interest and as a reference source for general class use. Inexpensive.

WYLIE, C. C. *Our Starland.* Chicago: Lyons and Carnahan. $0.88.
An excellent reference source in astronomy for the elementary school. Well written, wisely chosen subject matter, easily read. Helpful as a reference for a slow reader.

YOUNG, MARGARET SITLER. *Dicky and Peggy in the Orchard.* Chicago: American Book Company. $0.68.
A book about plants and animals for the early elementary pupil. Contains material about common living things. Can be used in first grade. Interestingly written.

HERE'S AN ANSWER TO THE QUESTION, "HOW SHOULD SCIENCE BE TAUGHT IN THE ELEMENTARY GRADES?"

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During the last three months it has been my good fortune to have participated in the meetings of science sections of a state teachers' convention and of several other educational conferences. Among the questions asked most frequently was, "How should science be taught in the elementary grades?" Of course, there is no definite answer to the question in view of the many prevailing attitudes towards the purposes of elementary science and the several schools of educational philosophy, but it is possible to compare opinions of outstanding educators and the practices in well-known schools as far as the method of teaching elementary science is concerned.

From more than five hundred references, methods of teaching elementary science have been reviewed, but in many instances the "method" has been confused with the "technique." Many of the techniques of teaching elementary science can be applied to any one of the several methods—a fact which fortunately narrows down to a workable basis the answer to our question. In reality, without splitting hairs, there are four methods of teaching science in the grades, each with certain advantages and disadvantages, and each elastic enough to fit into various educational philosophies and to employ several of the many techniques.[1]

A. THE FOUR METHODS

1. *The incidental method.* This method usually depends upon no course of study or prescribed procedure. It is solely dependent upon the classroom teacher's personality and influence to guide and inspire the children to "want" to study science through their interests and discoveries.[2] The procedure is generally to capitalize on some specimen of animal life or some mechanical device that a child brings into the schoolroom, and to use it as a cue for developing further interests and activities related to the object. The alert teacher, relying on the spontaneous interests in the object brought to school or seen on a trip, develops her "course of study" accordingly. There is no planned outcome, there is no specifically planned objective, but the activities develop along natural lines of interest. Several interest groups, several activity groups, many problems and investigations may be in progress at one time. Through these activities the other so-called "subjects" may be related in what seems to be the most natural way. The *incidental method* may be used to provide the entire course of study, or it may be supplementary. There are several variations of the procedure.

There is little doubt that where there is spontaneous interest in science material there is bound to be activity, and, in the hands of an alert teacher, the *incidental method* has produced excellent results. The main criticism is that there is no organized procedure and that the information gained by the child is a hodge-podge of miscellaneous facts that may be neither useful nor practical to him for his everyday living. It is further claimed that incidental education swings too far to the "play side" of education, and without guid-

[1] A good account of methods and techniques for the teaching of elementary science is included in: S. R. Slavson and R. K. Speer, *Science in the New Education.* New York: Prentice-Hall, 1934.

[2] The fall number of the *Franklin School News*, Vol. III, No. 1, published under the direction of Verna Parks in Eveleth, Minnesota, includes interesting descriptions of elementary-science activities, incidental and otherwise.

ance leads to undesirable consequences. The method is, however, used in many schools and has produced favorable outcomes especially in the primary grades.

2. *The definitely planned unit.* The unit method has several variations, of course, but in essence it means that a unit of work (an expression now considered out of style) is planned for the class and is to be completed within a certain number of class periods or a prescribed number of days or weeks of school. The procedure is usually charted by a planned course of study which undergoes continual change through curriculum revision. As a general rule, science topics are selected for certain grade levels and a plan is devised to build a basic program with related topics that will fully equip the child with information that is considered important for him to know.[1] While at first the plan sounds stiff and inflexible, in reality it is not, for in most cases ample opportunity is provided for caring for individual differences and interests.[2] Tests are usually prepared to follow the unit or are included in the unit at different points to measure achievement in the knowledge of facts. Children are usually allowed to proceed as fast as they can master the prescribed subject matter. The procedure usually employs the use of a series of work-sheets prepared in advance by the teacher or provided in the course of study, and, by means of the work-sheets, the laboratory technique is fully employed for performing experiments and recording results.

[1] For an excellent syllabus of science planned on a unit basis from the kindergarten to Grade VI see *Elementary School Science*, Vols. I and II, Public Schools, Glens Falls, New York, 1936, Irene Woodford, Science Supervisor. The syllabus contains over three hundred pages of activities and reference materials.

[2] An excellent unit plan for teaching elementary science including activities and provision for individual differences is *An Introductory Course in Science in the Intermediate Grades* by Bertha M. Parker, University of Chicago Press, Chicago, Illinois.

The definitely planned unit has several distinct advantages according to some points of view. It does, of course, prescribe the same general subject matter for each child up to the point of his individual differences, and here there is opportunity to drift a little into the incidental plan, which offers advantages for the accelerated child. As far as facts are concerned, it is obvious that the children learn an organized and prescribed amount of useful and valuable information, and, according to one interpretation, they are well drilled in the scientific method of cause and effect. The plans also incorporate an activity program with lectures and explanations at various points and additional discussions when they seem to fit into the scheme of things. The children also learn a well-organized procedure and tend to become reliable in self-direction. This plan, like the other, is flexible enough to employ many of the twenty or so techniques that are valuable for teaching elementary science.

The major objections to the plan are concerned with the method of determining the subject matter. What should be taught at different age levels? who is qualified to make this selection? and does the subject matter meet the children's needs and help them to become creative and capable of thinking for themselves? are some of the questions that arise. It has been said that children waste their time in repeating experiments that prove known facts which do not inculcate "scientific doing and thinking"[3] in the modern sense of the term. Then a lesser objection comes from the upper-grade teachers who claim that much of the prescribed subject matter is beyond the needs of the children and most of the science they learn has to be un-

[3] An unusual study related to children's behavior in science situations has been completed by Joe Y. West, *A Technique for Appraising Certain Observable Behavior of Children in Science in Elementary Schools.* Contributions to Education, No. 728. New York: Teachers College, Columbia University, 1937.

learned or retaught. However fair or unfair are the criticisms, the *definitely planned unit* has been the basis for some excellent science classes when the procedure is in the hands of a good classroom teacher and the science period is not simply a busy hour.

3. *The subject core unit.* The third method is similar to the second excepting that any "subject" may be the core of the unit and the other subjects radiate from it as they become related to the core subject. A social-science experience may be started. Perhaps it is related to the community. During the study, wind and weather may be considered, animals of the community may be studied, the communication systems, the soil, and other items that relate to the core subject may be in the field of science. Sometimes the related topics are prescribed ahead of time and sometimes they simply develop as described in the *incidental method.* In any event it is alleged that there are very few units of this kind that do not involve many opportunities for elementary science, and, as a matter of fact, in schools where this method is used the claim seems justified. Sometimes classroom groups or committees are appointed to investigate several topics, and demonstrations and reports are given to illustrate the relationships. Many of the techniques can be used in this plan as well as in the others. But the central theme of the unit, which has been prepared, is started in one subject field. Sometimes science itself is the subject core and the other phases of the curriculum are related to science. An illustration is offered by a fifth-grade class that studied the trees as a spring unit. From this study came a related study of wood, lumbering, paper, and other topics that are obvious.

The advantages claimed for this method are strongly centered about the idea of integration of subject matter, for this method offers one of the best opportunities for an integrated curriculum. It is also claimed that by this method much more interest and usefulness can be incorporated in the unit, and that it offers excellent opportunities for individual study and creative work. It is, of course, one of the most difficult units to prepare, for it includes some of the uncertainties of the *incidental method* as well as a doubtful outcome if the class is not creative and "research-minded." The chief criticisms are that the subject matter presented lacks uniformity, and that this type of unit is apt to reach into subject matter that is beyond the comprehension and need of elementary-school children. Lately it has been quite stylish to have children study and attempt to solve economic problems and social issues far beyond their understanding and ability to act. It has been maintained also that the *subject core method* encourages forced integration that is sometimes not natural and not important. It has been said that integration for the sake of integration is inexcusable and that planned relationships act as a crutch for the less gifted children while the normal or gifted children meet their needs for integration under their own power if properly guided. Integration will come when it is needed, as in real life, and should not be overdone in the science curriculum.

4. *The science concept unit.* The last method of the four general procedures uses a science concept as the subject, and the unit is developed as the interests and abilities of the class as a whole and as individuals are indicated.[1] It is not a freelance method but is under guidance of a teacher who directs the activities related to the concept that she is trying to develop. Many units of this kind appear in courses of study not as prescribed activities but as activities that have developed or as

[1] An example of a course of study illustrating the science concept unit is in *Curriculum Records,* National College of Education, Evanston, Illinois, 1932.

records.[1] The plan is well illustrated by the concept or topic "The Inter-relation of Living Things" which could begin with a study of any common living creature selected according to the interests or needs of the class. From this starting point the unit or activities would develop and broaden in scope until sufficient developments were underway to fully establish the principles of the concept in the minds of the children on their own level. The subject matter and direction are left to the discretion of the teacher and the outcomes are unknown until the unit runs its course or is gradually directed into another concept study. The plan incorporates as many other fields of interest as are naturally related.

The advantages claimed for this method are in many ways similar to those suggested for the *subject core method* excepting that in the *science concept method* the teacher is aiming to establish a general concept in the minds of the children instead of certain nuggets of prescribed subject matter. It is also said that in this way a unit can easily accommodate all the changing situations in the community and is therefore less restricted in procedure, although it should always be under guidance. Objections are again thrown at the hodge-podge of subject matter that might be included. The question also arises of determining what concepts[2] children of different age levels understand or need. The direction of this method must be in the hands of a skilful teacher who is sensitive to these relationships and recognizes them herself. Like the incidental plan, the *science concept unit* might prove dangerous to use in a large school system where a certain amount of uniformity is needed.

B. OPINIONS AND USES OF THE FOUR METHODS

It is apparent that the pros and cons of the four methods have not been exhausted but have been presented in a general way. It is also possible that some of the methods could easily overlap and that there are variations of all of them. However, considering the four methods generally understood in a broad sense, fifty-one well-known educators were asked to comment on the four methods and to suggest schools where good elementary-science programs could be observed. The comments and opinions of the selected group of educators were tabulated, and persons teaching in the recommended schools indicated in another survey which of the four methods they were using in their schools. Space does not permit a review of the comments, which were published elsewhere,[3] but the data in the table on page 42 will contribute to the answer to our question.

Judging from these data, which have been abridged from a more extensive study,[4] it seems evident that the specialists in curriculum and science education are more favorable to the *science concept method* than to the other three methods. In actual practice, nearly one-half of the

[1] The Shorewood Public Schools of Shorewood, Wisconsin, have just published an outstanding 200-page record of science activities entitled *Science Experiences* under the direction of Marjorie Pratt, Curriculum Co-ordinator. It is concerned with the kindergarten and Grades I and II and is an outstanding contribution.

[2] George W. Haupt, *Experimental Application of a Philosophy of Science Teaching in the Elementary Schools.* Contributions to Education, No. 622. New York: Teachers College, Columbia University, 1935.

[3] Thirteen important questions related to the teaching of elementary science were included in the original survey. For a summarized account of this part of the study see: "How Fifty-one Well-known Educators Answered a Questionnaire Concerning the Teaching of Science in the Elementary Grades," *School Science and Mathematics,* XXXVIII (November, 1938), 907–20; "What Are Your Opinions Concerning the Teaching of Science in the Elementary Grades?" *School Science and Mathematics,* XXXVIII (October, 1938), 732–39; and *Addresses and Proceedings* of the N.E.A., 1938.

[4] A comprehensive analysis of these data is given in a survey entitled *An Analysis of Opinions and Practices Concerning the Teaching of Science in the Elementary Grades,* by David W. Russell, Graduate School Library, Western Reserve University, Cleveland, Ohio, 1938.

COMPARISON OF OPINIONS OF EXPERTS WITH THE USE IN RECOMMENDED SCHOOLS OF THE FOUR METHODS OF TEACHING SCIENCE

Methods	Opinions of Specialists			Used in Recommended Schools *
	Favorable	Indifferent	Opposed	
Incidental	48%	20%	32%	48%
Definite Unit	30%	20%	42%	28%
Core Unit	62%	22%	16%	36%
Concept Unit	72%	18%	10%	48%

* Since some of the schools surveyed used more than one method of instruction, the percentage column does not total 100 per cent.

recommended schools used this method. Other comparisons can be readily made, but must not be considered conclusive. Comments on the reports from several of the schools indicated that, because of lack of equipment and general interest in elementary science, they were forced to resort to the *incidental method.* Other schools approved highly of the *incidental method* in the primary grades but preferred one of the other three for the upper elementary grades. This attitude seems to prevail among the specialists as well as among the teachers in the schools.

C. CONCLUSIONS

According to the survey and numerous comments at educational conventions and meetings, factors such as administration, equipment, limitations imposed by the upper-grade requirements, and other items are factors in selecting a method of teaching science in the elementary grades. From actual observation it seems that any one of the four methods can be used to bring forth good results and any one of them can be manipulated to cover most of the current views of educational philosophy. One of the important criteria is the attitude of the children and their responses, for it is common knowledge that all classes will not respond the same way to the same method if the children are allowed to think and to express themselves freely. How should science in the elementary grades be taught? Select the method that brings results that most nearly approach your aims, but, in view of the cross-sections of educational philosophy, a method built around the *science concept unit* idea will meet with the approval of prevailing opinion and practice.

Classroom Notes

A Child Applies New Learning to Past Accomplishments.—The first grade children had returned from a walk for shadow study. On the walk they had found their own shadows and the shadows of many objects. They had learned the relative position of the shadow in relation to the sun and the object. They eagerly drew pictures showing the sun and the object with its shadow.

Suddenly Mary Jane said, "Little Black Sambo needs to have a shadow, too." Lillian, who had drawn the picture of Little Black Sambo, ran to the easel. With black crayon, she drew Black Sambo's shadow opposite the bright yellow sun in the picture.

The spontaneity with which this was done was not only amusing but gratifying. Here was evidence of a "carry-over"—one of the most valuable outcomes of science teaching.

My Classroom Weather Bureau (Report by a Fifth Grade Child).—From my seat I can look out of one certain window and tell whether there is fog in the air or not. I can look through a certain gap in the trees and see far in the background a row of hills and part of Lake Nokomis. On these fall mornings when I come to school, I can hardly see the hills or the lakes. Sometimes I can't see them at all. That means there is fog. In the afternoon the lakes and the hills can be seen as plain as day. That means that the weather has changed. This is my weather bureau in a nutshell.

Freezing Water (Report of an experiment by first grade children).

The glass was not quite full of water.

We set it outside the window to watch the water freeze.

It was only two degrees above zero that day so it froze quickly.

We saw little points of ice on the inside of the glass.

The glass was heaped with ice.

Water "swells" when it freezes.

Smoke Makes a Good Barometer (Observation by a fourth grade).—We are making weather charts. We have been taking air pressure readings since November 2. We have noticed that on clear days the smoke from chimneys goes up and on cloudy days it goes down or out sideways. We have come to the conclusion that heavy air makes smoke go up and light air lets it down.

Editor's Note.—These classroom notes were collected or prepared by Jennie Hall, Adviser in Science, Minneapolis, Minnesota, Allegra Ingleright, Director of Elementary Education, South Bend, Indiana, and Florence Billig, Supervisor of Science, Elementary Schools, Detroit, Michigan and Association Professor of Science Education, Wayne University.

Shadows.—Second grade children decided to keep a record of the length of shadows to learn why they changed in length. They decided to draw John's shadow at 9 o'clock in the morning every two weeks from September until school closed for the Christmas vacation.

There was a discussion about the size of paper necessary for the shadow picture. Finally, a piece of paper about 4 by 6 feet in size was selected and the first shadow was drawn. Two weeks later John's shadow was so much longer that another piece of paper was added. How surprised the children were as weeks passed! Paper had to be added from time to time. The paper became so long that it tore as it was handled. During November the hall was the only place large enough to spread the record so that it could be studied.

Making the shadow record and observing the position of the sun together with the surprises and trials of lengthening the paper helped in developing an understanding of the relation between the lengthening of John's shadow and the position of the sun as fall advanced.

Jennie Hall,
Adviser in Science,
Minneapolis, Minn.

Labeling Trees in the Schoolyard.—For several years, a sixth grade class has kept labels on the trees in the schoolyard. To make a label, a priming coat of paint is put on a piece of tin 3 by 10 inches to which is added a coat of black paint. The common name of the tree is painted in white together with some information about the tree. A coat of shellac is then given to protect the label from weathering. The tin label is fastened to its particular tree out of reach of vandals. Labels of this kind make a walk in the schoolyard more interesting.

Ella Champion,
Elementary Grade Supervisor,
Niles, Michigan.

Lindy, the Canary.—After attending the National Canary Show at the Oliver Hotel, the 6B class spent considerable time trying to find a way to make money so as to purchase an amiable songster. The most profitable way seemed to be a sandwich sale. Mothers of the thirty-six pupils donated five hundred sandwiches, each consisting of two large slices of bread, lettuce, butter and a filling. Each sandwich was gigantic in size and sold for five cents.

The health aspect of the project was discussed. Each sandwich was wrapped in waxed

paper. Sandwiches alone seemed rather "dry eating," so bottles of plain and chocolate milk were also sold. (This brought an additional profit of two cents per bottle.) Class members with clean hands and aprons were in charge of this sale. At the close of the sale, the financial committee counted and wrapped the coins. When all bills were paid, there was a profit of $34.06.

The following day, the cage committee made a trip to the store to select a rectangular cage, a bird bath, a wire cleaning brush, seed, gravel, and bird vitamin food. The bird committee consisting of three members went to a bird shop owned by a man who is an officer in the National Canary Association. This man is famous for his excellent canaries and his interest in raising birds. The committee selected a canary that was a sweet singer but not a loud singer. It was brought back in a butter carton.

There followed much discussion as to the best name for the bird. At first "Butterball" was thought to be a good name, since he came to school in a butter box. The final vote showed "Lindy" to be the favorite name. This seemed a good name since he hopped around so much. It was soon noticed that the children were calling the water container the Pacific Ocean and the five perches the continents. Lindy made rapid flights from country to country.

Lindy sang beautifully and was trained to stop his singing when a certain pointer was raised. Sometimes he was so persistent and lengthy in his song that it was necessary to train him to stop for a time during certain work in the classroom. He was a most obedient bird and seemed to like the children. For the two severe winter months he was boarded out to the homes of several pupils. The drop of temperature in the building in twenty-four hours made us decide upon this course. The children who took care of him reported on him daily.

Editor's note.—Undoubtedly, in this study, there were many science outcomes involved in the selection of the canary, in choosing an appropriate cage, and in feeding and caring for the bird.

Spiders.—A fourth grade class became interested in spiders and made a study of common ones. The study extended over a period of five weeks. During this time many specimens were brought in and studied and moving pictures of spiders were shown. Following is a list of a few of the subject matter outcomes of the study:

A spider is not an insect because it possesses eight legs, two body parts and no wings. Insects have three pairs of legs, three parts to the body, and usually four wings.

Spiders make three kinds of silk—one kind for the web foundation, one kind for trapping prey, and another kind for the case to hold the eggs.

Different kinds of spiders make different kinds of webs. There are funnel, orb, triangle, sheet, and tent webs.

A spider web is most beautiful in the early morning when dew is on it. But food will not come to a damp web so the spider shakes off the dew.

The spider web is not a home for the spider. It is a trap for food.

Spiders build different kinds of homes, such as tunnels with trap doors, tents, dens, caves, and towers.

Spiders make egg cases for their eggs.

Each spider has its own way of making its egg case. Without being told, it makes it in the same fashion as its ancestors made theirs.

There are many different kinds of spider egg cases.

The food of spiders consists of beetles, flies, locusts, grasshoppers, and dragon flies. Spiders are cannibals. Their food habits make them friends of man.

A spider molts about nine times before it is an adult.

Spiders have enemies, such as ants, other spiders, wasps, snakes, lizards, and birds.

The black widow spider is a dangerous spider.

MYRTLE A. SWANSON,
Madison School,
South Bend, Indiana.

A Diary of Activities of a Hen and Her Chicks.—Shirley brought a canary egg to school. It was surprising to find, from discussion, that few children knew that a canary develops from an egg. This led to a discussion of eggs of other birds. Some children knew that chicks hatch from hen's eggs but none knew about or had seen the actual hatching of a chick.

A visit was planned and made to a poultry farm where the children saw eggs, a hen sitting on her eggs, and chicks hatching from eggs. A sitting hen and thirteen eggs were bought at the farm.

On returning to school, she was placed in her new home which had been planned and thought out before the trip. This home was a barrel placed on its side and partly filled with hay. Chicken wire nailed to four pieces of board formed a yard for the hen. Much attention was given to taking care of the hen and chicks. Children questioned their parents and neighbors for information. Other children in the school became interested in the project and gave many suggestions. The children kept a diary of the hen and her chicks for a period of five weeks.

The results of this activity were gratifying. All of the children watched with interest for the hatching of the chicks and cooperated in making plans and caring for the mother and her brood. Children who were named non-readers were stimulated to find stories about hens and little

chicks and ask other children to read them. Many children brought stories about hens and chicks from home. Making the daily record had many social values.

LAURA HOOPER, *Director of Elementary Grades and*
MARION J. KEYES, *Teacher*
Newton, Massachusetts.

Science Experiences in a Preschool.—In the Preschool there are three units. The youngest nursery school group contains twenty two-year-old children; the middle group, fifteen three-year-olds; and the oldest group, the kindergarten, twenty children of four or five years of age.

Science experiences form an integral part of the activities of these young children. Animals brought into the nursery school at various times during the year include rabbits, rats, mice, guinea pigs, a baby goat, a turkey, chickens, ducks, pigeons, dogs with suckling puppies, cats and kittens, canary birds, tortoise, turtles, gold fish, and salamanders. The children help in caring for the animals. Even the two year old children learn simple facts and make simple discoveries, such as: "the tortoise has a fatty pink tongue", "the baby bunnies drink from their mother", the salamander's front feet "look like hands", the baby goat "cries like my brother". Animal life abounds in the environment. There are flies that "wash their hands without soap or water". There are tadpoles in an outdoor pond that turn into "finger-nail-big, little frogs". There are ants, lady-bugs, butterflies, moths, lizards that "run faster than your hands can catch", and birds galore. Before the children notice these, the teacher needs to be a "noticing" kind of person. Her interests in the small things around her lead children's interests into similar channels.

Simple discoveries regarding plants are made through actual experience with them. Some plants grow from seeds, others from bulbs. There are different kinds of seeds—olives with their hard seed inside, red berries with many tiny seeds imbedded, weeds, roses, beans, and peas.

Other science experiences relate to weather: When the sun shines, it dries the doll's clothes that have just been washed; when the wind blows, it "whistles down the leaves"; and when the rain falls, it "turns the dust into mud".

These are simple facts but the stuff that science is made of. The teacher who is sensitive to and aware of them is the teacher who helps little children reach out, as they grow, to further science experiences.

DOROTHY W. BARUCH,
Director of Preschool,
Broadoaks School of Education,
Whittier College,
Whittier, California.

Eight Degrees Above Zero.*—It was the first cold day of winter. There was frost on trees, fences, and window panes. Snow and ice covered the streets and ground. The children in a second grade class came to school bundled up. They talked about the weather and the changes that accompanied it. They wanted to know what the radio reporter meant when he said, "It is eight degrees above zero this morning".

A large wall thermometer in the room took on a new meaning and importance. Examination showed that the top of the red line in the theromometer was at the line marked 70. The children found other lines marked 60, 50, 40, 30, 20, 10, and one marked zero. The teacher explained that when the top of the red liquid in the tube was at the line marked 70, it was warmer than when the top of the red liquid was at the line marked zero. It was decided to hang the thermometer outside of a window to find out if it would tell that the air out-of-doors was eight degrees above zero. Immediately, the red liquid started to go down and finally stopped at a line marked 10 degrees above zero. Harry wanted to know if the liquid went down farther if it would be colder. After some discussion it was decided that since the reading was ten instead of eight that it must have gotten warmer since the radio report was given. The thermometer was taken back into the room and immediately the red liquid began to go up in the tube. It stopped at the line marked 70 just where it had been before. It was then taken out-of-doors and again it indicated ten degrees above zero.

The children decided that they would like to find out what the thermometer would tell them about the air during the following week and maybe the red line would go down to zero. They selected groups to tkae readings at morning, lunch time, and before going home in the afternoon. Each group devised a chart for keeping records as a way of reporting the findings to the class. So that the recorded readings could be more easily seen by everyone in the room, the pupils and teacher made a model of a thermometer that could be adjusted to any reading. A board six inches wide and four feet long was painted black with the scale in white. The ends of the ribbon made by sewing together equal lengths of white and red ribbon, were slipped through openings at the top and bottom of the scale. The ends of this ribbon were fastened together so that it could be adjusted easily. Some children made individual model thermometers which they adjusted as the out-of-door temperature changed. Thermometer readings were taken at home and compared with

* *Editor's Note.—This and each of the following classroom notes emphasizes the way in which advantage was taken of natural situations as they arose in the common everyday experience of children. They are not isolated studies but are phases of the outlines of study in science which relate to the science interests and associations of children in their community.*

school readings. One child found the temperature readings in the evening paper. This stimulated other children to look for them and resulted in a disccussion of why temperature readings were important enough to be put in the daily papers. They were delighted when their school readings corresponded with those in the paper.

The children found that thermometers were common at home as well as in school. There was the one used by the nurse and doctor to find out whether boys and girls were sick; the one in the oven that tells when it is hot enough to bake; the one used in making candy and jelly; the one in the living room to tell when it is warm enough for comfort; the one on the back porch that tells how cold it is out-of-doors and when to bundle up; and the one outside of the door of the corner drug store.

This study gave pleasure and satisfaction in answering a real problem through first-hand experience with an instrument that is significant in social and industrial life. It is important in contributing to an understanding of weather and how things behave with temperature changes. The interest in reading a thermometer and its relation to weather changes extended over a long period of time after the particular study had been completed.

KATHERINE BANNING,
Directing Teaching in Science,
Roosevelt School,
Detroit, Michigan.

Monarch Butterflies in the School Garden.—When a first grade class was in the school garden gathering flower seed for planting the following spring, the children became interested in the many insects found around the plants. They were particularly attracted to monarch butterflies flying from flower to flower. They wanted to know what the butterflies were doing. The children and teacher watched them alight on flowers. One was seen uncoiling its proboscis, putting it into a flower, recoiling it, flying to another flower and repeating the process. This was watched over and over again. The teacher then explained that the butterflies were getting food, that their food was nectar in flowers, and that a butterfly gets nectar from flowers through its proboscis in much the same way that children drink milk through a straw. A new problem had arisen—what is nectar and can we see it? Nectar was found in petunia flowers. The boys and girls readily saw how the long proboscis of the butterfly helped it get nectar from flowers like the petunia and sweet william.

So that butterflies might be watched at close range, some were caught in insect nets made by the children. They were placed in light, airy cages also made by groups of children. Each cage consisted of a roll of mosquito netting with a cake pan for the top and one for the bottom. Bouquets were placed in each cage. After a short time the butterflies took nectar from the flowers. The children were delighted when butterflies took sugar water from drops on their fingers. One butterfly would fly immediately to the finger as soon as it was put in the cage. It seemed as contented with sugar water as with nectar from a flower.

Through first hand experience in garden and schoolroom, the children gained an understanding of how the monarch butterfly gets its food. This is the beginning of understanding a significant relationship between plants and animals with which children are associated in everyday living. They observed accurately and drew conclusions on the basis of what they had seen. The teacher contributed when the children needed and asked for information. She assisted in solving a problem out of which developed a new problem. Through frequent associations with the monarch butterfly, such as watching it carry on normal activities of living, by taking care of it, and by talking about it, the children became acquainted with some of its habits and characteristics that distinguish it from other insets. The assignment was made by the class—to look around flowers in gardens and vacant lots to find out what other butterflies do.

During frequent activities concerned with the garden, the children learned to know many insects commonly found around plants. They learned to think of their garden as an association of plants and animals and as an interesting place in which to work.

MARION CHINNOCK,
Science Teacher,
Poe School,
Detroit, Michigan.

Red-Winged Blackbirds Return.—During the winter a second grade class had been concerned about birds finding food when snow and ice covered weeds, shrubs, and ground. They had made a bird feeding station and had kept it stocked with food. They were bird conscious. It was not surprising, then, that in March Paul reported that on his ride in the country he had seen a bird that was different from any he had ever seen before. It was black with red on its wings. It was sitting on a big stem growing in a field partly covered with water. Immediately the other children became interested and wanted to know more about this new bird. From a number of pictures in the room Paul found one of his bird and to his delight said that it was sitting on the same kind of a stem as the one he saw.

All of the children wanted to go to Paul's swamp to look for red-winged blackbirds. Since, at this particular time it was impracticable for everyone to visit the swamp, it was decided that four children and the teacher should make the trip and report to the class what they found. The class made a list of questions about the red-winged blackbird and its home that they

wanted answered. The children who did not go on the trip, planned to look for pictures and stories about red-winged blackbirds in their readers, in library books, and in story books at home.

During the visit to the swamp, many red-winged blackbirds were sene. So many things were learned about them, and their home that making a vivid report to class became a real problem. They finally decided to take home some of the things they found and make a small swamp in the sandtable. To help give an idea of how the swamp looked, the teacher took a picture of it. Then with a car filled with cat-tails, weeds, moss, willow, skunk cabbage, a marsh marigold, and other plants, a deserted red-winged blackbird's nest, and a frog, the happy children went home anxious to tell their story.

The children reported what had been seen on the trip. Those who did not go to the swamp reported that red-winged blackbirds spend the winter in the south and come back to Detroit in the spring and that flocks of father birds come first and are followed, a couple of weeks later, by flocks of mother birds. The children then made a swamp in the sandtable as the home of the red-wing; a colored picture of a swamp on the blackboard; and two bulletin boards—one for the room to show the return of the birds to Detroit and one for the hall to tell the children in the school that red-winged blackbirds had come back. On completion of the swamp, one little girl said, "It looks just like the swamp we saw only the birds aren't singing." Fortunately there was a victrola record of bird calls in the Auditorium file. This was borrowed and the red-wing's song was played a number of times making the story complete.

Through this study there was opportunity for children to explore a phase of the environment that contributed definitely to enjoyment and enrichment of their life in a community. As a result the community became more intimately a part of the educational experiences of the children.

DOROTHY E. FOX,
Science Teacher,
Columbian School,
Detroit, Michigan.

Digests of Unpublished Investigations

A CRITIQUE FOR THE EVALUATION AND DEVELOPMENT OF SCIENCE COURSES OF STUDY FOR THE PRE-COLLEGE YEARS

BY PHILIP GUSTAF JOHNSON *

UNIT I

PROBLEM.—To trace the historical development of courses of study for the teaching of science in the elementary school, the junior high school, and the senior high school.

METHOD.—An analysis was made of a large number of articles and reports in educational periodicals and books, and of reports of state superintendents, to determine the significant trends in the development of courses of study in science for the pre-college levels.

FINDINGS.—1. The development of courses of study in science for the elementary school has followed four general stages: (a) Introduction, characterized by a few diverse beginnings; (b) Rapid Development, characterized by considerable diversity with respect to content and organization but in general conforming to a few characteristic and distinct types; (c) Reaction, characterized by a movement toward greater uniformity with respect to content and organization; and (d) Analysis, characterized by the introduction of content and organization based on specific objectives. A Concept Period characterized by an organization based on principles of science is beginning.

2. The organization of courses of study in science for the secondary school has developed through three periods: (a) a topical organization, characterized by the logical organization of course content; (b) an organization in terms of specific objectives, characterized by the statement of desired outcomes along with a more or less logical organization of content designed to achieve these outcomes; and (c) a unit organization characterized by a wide diversity of interpretations of what constitutes a unit, and including an organization based on scientific principles and concepts. Courses of study for the early secondary school levels have evolved more rapidly through these periods than have those for physics and chemistry.

UNIT II

PROBLEM.—To determine the extent to which the judgments of teachers regarding the development, organization, and content of courses of study in science, and methods of teaching science at pre-college levels are influenced by the teaching experience, science preparation, and professional preparation of these teachers.

METHOD.—An extensive survey was made of professional literature, including many courses of study, to ascertain the various plans for developing and organizing content, and the various suggestions relative to teaching methods. Typical plans, schemes of organization, general content, and teaching methods were described in short statements and arranged in lists of closely related items. These were submitted to six selected juries composed respectively of rural, elementary-city, junior-high-school, and senior-high-school teachers, supervisors of science, and leaders in science education, with the request that they approve or disapprove each item. The evaluators were also asked to furnish information concerning their own teaching experience, science preparation, and professional preparation. Those within each of the six groups who submitted answers, further grouped into "low" (those in the lowest quartile), "medium" (those of the middle 50 per cent), and "high" (those in the upper quartile) groups on the basis of each of these three factors and the responses of each group, were summarized and compared. A total of 240 judges were involved in this unit of the study.

FINDINGS.—1. Rural-school and junior-high-school teachers with high subject-matter and professional preparation favored a plan whereby the state would distribute suggestions for use by teachers in preparing their own courses of study. Supervisors and leaders in science education favored the preparation and distribution of courses of study by the state. Elementary-city and senior-high-school teachers revealed little or no tendency to be influenced in their attitudes towards the preparation of courses of study by their experience or their subject-matter preparation.

2. The amount of experience appeared to have but little influence on the content desired in courses in science. The usual sections, "as those devoted to aims and objectives, methods, suggestions for various grades, and the like," were favored except those relating to administrative details and the characteristics of a teacher. Junior-high-school teachers with high professional preparation favored courses of study which provided much factual information while senior-high-school teachers with high science preparation favored the inclusion of examples of effective teaching plans. Supervisors with high professional preparation favored the inclusion of suggestions of basic content and optional materials while those with high science preparation favored suggestions for effective administration of the courses as well as for factual information to be included.

* Unpublished dissertation for the degree of Doctor of Philosophy, Cornell University, 1933.

3. The contributors did not favor definitely the general utility[1] of science courses of study. The construction of science courses of study which would be generally useful in schools of different types of organization was favored by a comparatively larger percentage of supervisors and leaders in science education than of any other groups. Rural-school teachers favored the state preparation of junior-high-school courses of study which would be useful for the seventh and eighth grades of a rural school.

UNIT III

PROBLEM.—To determine the nature and value of specific items of content, and plans for development and organization of courses of science at pre-college levels.

METHOD.—Two hundred twenty-three statements of principles and of philosophy governing the selection of content, and 82 similar statements governing the development and organization of content were described in short statements. These statements, organized in related sections, were evaluated with respect to their "idealness" and "helpfulness," by a large number of qualified teachers, supervisors, and experts, including 47 per cent of the respondents of Unit II.

FINDINGS.—The following statements represent guiding principles and philosophy which many evaluators judged to be ideal or very helpful:

Course-of-study suggestions for science teaching should be organized in several loose-leaf publications. These should be arranged to fit into a common folder and supplements or revised sheets issued from time to time.

The general aims should be discussed in the early part of the publication and the specific aims interwoven with the suggested subject matter and methods.

The science subject matter should be organized separately with occasional correlation with other subjects.

The subject matter within the science course should have its organization based on pupil needs and interests; the teacher to sense these and guide the development of the subject-matter material.

The methods should be discussed entirely in connection with the subject-matter material, i.e., the subject-matter divisions followed by a discussion of suitable methods.

The references should be placed both in connection with the parts to which they relate and in an organized list.

The bibliography should contain the name of the author, title, publishing company, price, and a brief statement or abstract indicating the contents of the reference.

The suggested subject matter and methods should be interesting or capable of being made interesting; should be suited to the pupil's level of accomplishment; should be based on the pupil's previous science experiences; should be adapted to the school organization; should be concerned with the "at home" elements of science; should be based on research; should provide for much pupil activity; should seek to develop principles rather than present more or less isolated facts; should be different for a rural school from those of a city school; should simplify the problems of supervision; and should make science experiences available for all pupils.

The science committee for science course-of-study development should involve the co-operation of educational advisers, teachers of science in public schools and in normal schools and colleges, and supervisors in school systems and training institutions.

UNIT IV

PROBLEM.—To assemble statements of philosophy and guiding principles for ready reference.

METHOD.—"An analysis was made of materials in seven year-books and special reports of committees. Statements of philosophy and guiding principles were copied and listed in the various pre-college groups as indicated by the context in which the statement was found."

FINDINGS.—Forty-five statements were obtained and classified. Samples of the statements follow:

The material should belong to the activities and experiences of childhood, and to the child's biological and physical environment, leading from the familiar to the unknown.

The committee suggests that differentiation (for groups of differing abilities) should be based on the amount and kind of work done with each topic rather than upon a distribution of topics.

Repetition of a subject is not to be condemned when new types and new problems are used to satisfy the broadening interests of children. . . . The high-school teacher should recognize after egiht or nine years' work in the grades, that the laws of Nature and Life have been taught.

The junior-high-school pupil is living in the age of hero-worship and the science course of study may well be presented largely in terms of biographies.

It is proposed that the curriculum in science for a program of general education should be organized about large objectives, that understanding and enlargement of these objectives shall constitute the contribution of science teaching to the ultimate aim of education, and that the course of study be so organized that each succeeding grade level shall present an increasingly enlarged and increasingly mature development of the objectives.

It is suggested that we may expect to accomplish a grade placement of materials relating to this objective by analyzing the major generalization into the smaller generalizations, principles, and concepts from which it has been synthesized and by subsequent subdivision of these until they are reduced to elements which are appropriate for the different grades.

The science of the elementary school should be well-balanced and derived from the major fields of science. It should, however, not be organized or treated about the separate sciences, but rather about the problems and situations which are challenging, many of which may integrate the separate fields.

The science course of the new high school should develop a definite sequence from year to year and from one unit of instruction to the next so that the pupils as they progress through the school will meet problems of increasing difficulty and build continuously on that which has gone before and in relation to that which is to come. . . . The science work of the high school needs to be fully integrated with the science taught in the elementary school, and with the instruction that is to follow later at the college level.

Curriculum organization and content (of rural schools) have been and are formal and unrelated to the life of the child, community, or society, while the environment abounds with vital material. It is organized upon the subject-to-be-learned basis, while the child's life has been teeming with potentially educative activities and experiences.

From the point of view of supervision, the course of study is the point of attack upon subject matter, method, technique, and device for the determination of pupil achievement and of the creative leadership and growth of the supervisor.

[1] "General utility refers to the use of a course of study in different schools, i.e., the use of elementary-city courses of study in rural schools and *vice versa;* the use of a VII–XII general-science course of study in the seventh or eighth grades in a rural school or in an elementary school on the I–VIII plan, as well as in the ninth grade of a high school on the IX–XII plan."

Editorials and Educational News

PROGRAM OF THE TWELFTH ANNUAL MEETING OF THE NATIONAL ASSOCIATION FOR RESEARCH IN SCIENCE TEACHING

CLEVELAND, OHIO
FEBRUARY 26, 27, 28, 1939
Headquarters: Hotel Allerton

Executive Committee

S. RALPH POWERS, *President*
FRED ANIBAL, *Vice-President*
ELLSWORTH S. OSBOURN, *Secretary-Treasurer*
HANOR A. WEBB
CHARLES J. PIEPER

Sunday Evening, February 26, 1939
6:30 P. M.

Dinner Meeting for Members
Hotel Allerton, Parlor A

S. Ralph Powers—*Presiding*

Dinner.

Presidential Address.

Business Meeting.

Report of the Secretary-Treasurer.
Committee Reports.
Association Business.
Discussion.

Monday, February 27, 1939
9:00 A. M. Parlor C, Hotel Allerton

S. Ralph Powers—*Presiding*

Business Meeting.

Report of Nominating Committee.
Election of officers.
Unfinished Business.

9: 30—*Report of the Committee of the National Association for Research in Science Teaching. Appointed to Cooperate with the College Entrance Examination Board in Proposing New Definitions of the Requirements in Science at the Secondary Level.*

Ralph E. Horton, Seward Park High School, New York City.

10: 00—*A Review of Research in Science Teaching for the Current Year.*

Charles J. Pieper, School of Education, New York University, New York, N. Y.

10: 30—*Discussion.*

Francis D. Curtis, School of Education, University of Michigan, Ann Arbor, Mich.

11: 00—*Developing Problem Solving Abilities in the Classroom.*

Edith Selberg, Colorado State College of Education, Greeley, Col.

11: 30—*A Comparison of the Relative Effectiveness of Two Methods of Teaching General Science.*

J. Darrell Barnard, New York University, New York City.

12: 00—*Teaching Nutrition in Biology Classes.*

An Experimental Investigation of High School Biology Pupils in Their Study of the Relation of Food to Physical Well-being.

N. Eldred Bingham, Lincoln School of Teachers College, New York, N. Y.

Tuesday, February 28, 1939
9:00 A. M. Parlor A. Hotel Allerton

Fred Anibal—*Presiding*

Announcements.

9: 15—*Panel Discussion on Teacher Education in Science.*

Fred Anibal, Stanford University, Palo Alto, Cal., *Chairman.*

Members of the Panel:

G. P. Cahoon, Ohio State University, Columbus, Ohio.
Anita Laton Conrad, University of California, Berkeley, Cal.
Earl R. Glenn, State Teachers College, Montclair, N. J.
John Pilley, Wellesley College, Wellesley, Mass.
Paul B. Sears, Oberlin College, Oberlin, Ohio.
A. N. Zechiel, Curriculum Staff, Commission on Relation of School and College, Ohio State University, Columbus, Ohio.

P. M.

12: 30—*Luncheon and Business Meeting for the Executive Committee.*

Tuesday, February 28, 1939
2:00 P.M. Junior Ballroom, Hotel Allerton
Joint Meeting With Society for Curriculum Study.

S. Ralph Powers—*Presiding*

Topic: *Socialization of Science.*

1. The *Future of Scientific Research as a Social Force.*
   C. C. Furnas, Yale University, New Haven, Conn.
2. *Science as An Organized Field of Study.*
   Victor H. Noll, Michigan State College, East Lansing, Mich.
3. *Science in General Education.*
   R. J. Havighurst, General Education Board, New York City.
4. *The Place of Science as Revealed in Recent*
   Alto, Cal.
   Programs of Curriculum Development.
   Fred Anibal, Stanford University, Palo
5. *Life Science in the New General Education.*
   Paul B. Sears, Oberlin College, Oberlin, Ohio.

PROGRAM OF THE TWENTIETH ANNUAL MEETING OF THE NATIONAL COUNCIL ON ELEMENTARY SCIENCE

CLEVELAND, OHIO
SATURDAY, FEBRUARY 25, 1939
Hotel Statler

Morning Program

Address by Miss Anna E. Keller, District Supervisor in charge of science in the laboratory schools, Chicago, Illinois

A demonstration lesson with fifth grade pupils by Miss Edna Byrne, Doan School

Address by Ira C. Davis, University High School, Madison, Wisconsin

Luncheon Program

Speaker—David Dietz of the Cleveland Press. Subject: *Science and the Future*

Afternoon Program

Joint meeting of National Council on Elementary Science and the National Association for Research in Science Teaching

PROGRAM OF THE TWENTIETH ANNUAL CONVENTION OF THE NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

CLEVELAND, OHIO
February 24, 25, 1939
Headquarters: Carter Hotel

General Purpose: To provide authoritative and stimulating discussion of classroom problems so as to add zest to one's professional life and joy to one's teaching.

General Theme: Making Mathematics Teaching Function.

Designed For: Arithmetic teachers in the grades, high school teachers of mathematics, and those who train mathematics and arithmetic teachers.

Program

The complete program will be found in *The Mathematics Teacher* for January. A partial list of speakers follows here:

1. *Two general sessions.* United States Commissioner J. W. Studebaker, W. W. Beatty, M. L. Hartung, and F. R. Moulton, Secretary A.A.A.S., banquet speaker.
2. *Two arithmetic sessions.* A. C. Rosander, F. B. Knight, H. O. Gillet, F. S. Breed, L. J. Brueckner, F. E. Grossnickle, C. L. Thiele, H. G. Wheat, G. M. Wilson, J. T. Johnson, W. A. Brownell.
3. *Four Junior and four Senior High School sessions.* W. S. Schlauch, Ira Davis, J. H. Hlavaty, Bjarne Ullsvik, H. E. Grime, Harold Fawcett, Gilbert Ulmer, Leroy Schnell, R. G. Wilbur, Alma Bower, W. O. Smith, J. M. Jacobs, Howard Whipple Green, W. E. Betz, E. R. Breslich, L. C. Karpinski, Martha Hildebrandt, Vera Sanford, Raleigh Schorling, and several others.
4. *One Teacher Training session.* J. P. Everett, L. H. Whitcraft, L. E. Boyer, W. W. Rankin.
5. *General.* Exhibits from Cleveland schools, luncheon and dinner meetings, group breakfasts, get-acquainted tea and many opportunities for professional contacts, for making new friends, and for exchanging experiences.

Committee on Local Arrangements: A Brown Miller, Shaker Heights High School, *Chairman;* H. E. Grime, Supervisor of Mathematics of Cleveland Schools, *Vice-Chairman.*

Abstracts

ELEMENTARY SCIENCE

LATON, ANITA D. et al. "A Handbook for Student Teachers and the Supervisory Staff." *University High School Journal Staff* 16: 157–219; June, 1938.

This Handbook was prepared by members of the University High School, Claremont Junior High School and the Sante Fe Elementary School. It is intended primarily for the use of student teachers and the supervisory staff. The emphasis throughout is on the course in supervised teaching. In it is outlined the entire program for the professional education of teachers at the University of California. —C.M.P.

PALMER, E. LAURENCE, KELLOGG, BYRL JORGENSEN, KENNEDY, ANNA CLARK, and GORDON, EVA L. "The Elementary Science Library." *Cornell Rural Leaflet* 32: 3–75; September, 1938.

This is an excellent teacher manual on the selection of science books for teachers and pupils. An annotated bibliography of more than 50 pages is included. A summary of Leaflets and their contents 1920–1938 is included. —C.M.P.

PALMER, E. LAURENCE. "Waterways in Fall." *Cornell Rural School Leaflet* 32: 3–32; November, 1938.

The first part of the Leaflet discusses life in water and how to establish an aquarium. Following this discussion are four pages on water plants—two of illustrations and two on keys. Then follow several pages of illustrations and keys on water animals. The key includes: (1) common name, (2) scientific name, (3) description, (4) where found, (5) distribution and classification, (6) life history, (7) behavior, (8) reaction to environment, and (9) economic importance. The last six pages are devoted to illustrations of fishes and a key giving name, habitat and range, life history, use, and classification. —C.M.P.

BLOUGH, GLENN O. "How Animals Live Together." *The Instructor* 47: 41–50; September, 1938.

This excellent article, profusely illustrated, gives an overview of teaching procedures, with pupil and teacher bibliography for teaching this unit on the three grade levels: primary, middle and upper grades. —C.M.P.

BLOUGH, GLENN O. "Lessons in Elementary Science." *The Instructor* 48: 26; 68; January, 1939.

This article discusses objectives and general procedure in elementary science. Lesson suggestions are included on: (1) keeping a weather chart; (2) discussing a superstition; (3) determining the reason for a game law; (4) agriculture quarantine, and (5) using newspaper clippings. —C.M.P.

CONNELLEY, RUSSELL L. "The Telephone and Telegraph." *The Grade Teacher* 56: 47; 72–73; October, 1938.

This is an outline study unit on the lives of two famous inventors. —C.M.P.

MARTIN, MARY R. and STUDT, EARL. "Magnets." *The Grade Teacher* 56: 12–13, 74–75; November, 1938.

This is a fairly complete elementary science unit on magnets. Possible approaches, topics for discussion, activities and bibliography are included. —C.M.P.

DAVIS, C. B. "Seeds and Nuts." *The Grade Teacher* 56: 14, 68–69; October, 1938.

This is an illustrated elementary science unit, the material of which may be "adaptable to all grades". —C.M.P.

ANONYMOUS. "Safety Education Thru Schools." *Research Bulletin of N. E. A.* 16:240–294; November, 1938.

The Bulletin discusses: (1) Current school practices in safety education, (2) Methods of safety teaching, (3) Sources of instructional materials, (4) Necessary improvements in the teaching of safety in the schools, (5) Problems that lie ahead, (6) Where safety education aids may be obtained and (7) Reviews of safety films and slides. —C.M.P.

WYLER, ROSE. "Radio: An Elementary Science Teaching Tool." *Teachers College Record* 40: 222–228; December, 1938.

The article describes the present status of the radio as a tool in science teaching. Cleveland and Rochester have a systematic program for using the radio in elementary science teaching. Teachers need to know more about available programs and how to use them most effectively in their teaching. Much experimentation on the most effective use of radio programs in the classroom is needed. —C.M.P.

HITCHINGS, J. M. "Interesting Facts About Bees." *The Iowa Science Teacher* 4:119–122; December, 1938.

This is an excellent summarization of facts and observations about bees. —C.M.P.

FINCH, ELMER A. "Second Graders Learn Photography." *The Journal of the National*

Education Association 28:20–21; January, 1939.
This illustrated article relates how photography was made an interesting science unit in the second grade in the Amityville, L. I. N. Y. schools. —C.M.P.

McCARTHY, NORA. "A Unit on Iron." *The Instructor* 48:15, 66–67; January, 1939.
This is a third grade unit. The unit is divided into the following phases: (1) Origin of the unit, (2) Objectives, (3) Development, (4) Activities, (5) Outcomes, (6) Culminating activities, and (7) Bibliography. —C.M.P.

ARNOLD, DWIGHT L. "Testing Ability to Use Data in the Fifth and Sixth Grades." *Educational Research Bulletin* 17:255–259, 278; December 7, 1938.
This is a study of the ability of fifth and sixth grade pupils to use data and do critical thinking. A general conclusion from this study is that pupils in these grades can use data and do critical thinking if adequate consideration is given to purposes and procedures. —C.M.P.

RUSSELL, DAVID W. "What Are Your Opinions About Teaching Science in the Elementary Grades." *School Science and Mathematics* 38:732–739; October, 1938.
This article is primarily a list of 13 questions asked in a questionnaire study. The 13 questions had a total of 85 subordinate questions for checking purposes. —C.M.P.

CULBERTSON, A. C. "Large Wild Mammals of California." *Science Guide for Elementary Schools* 5:1–26; October, 1938.
The larger mammals of California are described and discussed in this issue. There is a key to classification, suggestions to teachers and bibliography. —C.M.P.

BRAUN, O. M. "Domestic Birds." *Science Guide for Elementary Schools* 5:1–42; September, 1938.
This bulletin discusses: (1) Origin and early history of domestic birds, (2) Classification of fowl, (3) How domestic fowls are cared for by man, (4) Essentials of incubation, (5) Production of eggs for market and for hatching, (6) Selecting a profitable hen, (7) Domestic birds of minor importance, (8) Enemies of domestic man, (10) Suggestions to teachers, and (11) birds, (9) How domestic birds are used by Bibliography. —C.M.P.

GILBERT, WINIFRED. "A Fall Unit on Insects." *The Iowa Science Teacher* 4:72–76, 88; September, 1938.
This is an elementary science unit intended for fourth and fifth grades. Among the topics considered are: (1) Values of the study, (2) Ways of introducing the unit, (3) Class procedures, (4) Outcomes, (5) References for teacher and pupils. —C.M.P.

JUNE, MARTIN W. "Grasshoppers and Locusts." *The Grade Teacher* 56:16–17, 80–81; September, 1938.
This is an illustrated natural science unit intended to be "adaptable to all grades." —C.M.P.

KIMMEL, MAURICE E. "From Egg to Chick." *The Grade Teacher* 56:31, 97; September, 1938.
Short unit showing six stages in the development of a chicken, the initial stage being when it first breaks the egg shell. —C.M.P.

ILOF, PHILIP M. "Transportation." *Science Guide for Elementary Schools* 4:1–43; May 1, 1938.
This issue discusses the following phases of transportation: (1) early types of transportation; (2) transportation on land, including the steam engine, internal combustion engines, the electric motor, and automobiles; (3) transportation on water; and (4) air transportation. —C.M.P.

MACBRIDE, DEXTER, EDITH. "Safe-guarding the Health of Pennsylvania's Children." *Science Leaflet* 12:36–38; 24–34; 37–38; October 20, October 27, and November 3, 1938.
This article tells what one state is doing in health work, but it is of significance to all health workers and science teachers. —C.M.P.

DRISCOLL, J. P. "What You Can Do With the New Magnets." *Popular Mechanics Magazine* 70:753–755; November, 1938.
A dozen or two little tricks, some useful, others entertaining which may be done with the new small alnico magnets. —O. E. Underhill.

CARR, WILLIAM H. "Beaver, Builder of Empire." *Natural History* 42:100–106; September, 1938.
This is an interesting article, with some splendid photographs, on the activities of beavers. —C.M.P.

HERMANNI, EDWIN G. and RITCHIE, HAROLD S. "Winds." *The Grade Teacher* 56:47, 74; January, 1939.
This is on elementary science unit based on the following three questions: (1) What causes winds? (2) How does air movement at the equator cause a regular system of winds? (3) How is rainfall on the earth's surface affected by regular winds? —C.M.P.

KING, GEORGE. "Turning White." *The Grade Teacher* 56:18, 81; January, 1939.
This is a short lesson in nature study about animals that change color with the seasons: the ptarmigan, the hare, the arctic fox and the weasel. —C.M.P.

New Publications

Symposium. *Teaching Aid Bulletins for Elementary Science.* New Rochelle, N. Y.: Elsie Flint Neuner, Elementary Science Supervisor, 1938. $0.25 each.

This is a series of elementary science bulletins written by teachers for teachers that depict actual classroom situations in the New Rochelle Schools. The aim of the series is to emphasize various classroom activities that may be used to enrich the elementary science program. The bulletins were prepared under the direction of Elsie Flint Neuner, Supervisor of Elementary Science. Teachers of elementary science in other systems should feel grateful that these bulletins have been made available. Each bulletin is in an attractive cover and the usability of the material has been tested by classroom experiences.

Bulletin I—Aquariums and Terrariums as Teaching Aids in Elementary School Classrooms.
Bulletin II—The Museum as a Teaching Aid in Elementary Schools.
Bulletin III—Experiments and Demonstrations: Their Place in the Elementary School.
Bulletin IV—Animals in the Elementary School Classroom.
Bulletin V—Motion Pictures and Lantern Slides.
Bulletin VI—Indians in the New Rochelle Region.
Bulletin VII—A Study of Local Trees.
Bulletin VIII—An October Day: What We Should See.
Bulletin IX—A List of the Newer Science Books for Elementary School Library and Classroom Use.

—C.M.P.

Neuner, Elsie Flint. *Conservation and the Christmas Season.* New Rochelle Public Schools: Elsie Flint Neuner, Elementary Science Supervisor, December 1928. 6 p. $0.25.

This illustrated bulletin, emphasizing conservation of plant life, describes trees used for Christmas trees (Balsam, Fir, Red Spruce, White Spruce, Norway Spruce, Black Spruce, White Pine, and Hemlock), plants used for wreaths and garlands (Mountain Laurel, Black Alder, Bayberry, Western Huckleberry, Club Mosses, American Holly, Rhododendron, Arborvitae, Retinospora filifera, Retinospora plumosa and Mistletoe), dish gardens and terrariums, and potted plants. A Christmas tree for the birds is urged. —C.M.P.

Bruce, Guy V. *Children's Play-at-Science Series:* Book I—World of Air and Water, 96 p.; Book II—Heat, Fire and Fuels, 75 p. Newark, N. J. (N. J. State Teachers College): the author, 1938. $1.15 each.

Do not let the title of this series mislead. It may be "play" in the sense that the activities described will be carried on with enthusiasm and enjoyment by elementary school children, but it is real science. These two volumes are the first of a series of seven, the first six of which deal with the physical sciences. There has been for some time a tremendous need for such a book as this. It brings together under unit headings about 125 simple experiments (in the two volumes already published) and activities, many of which are simple enough to fit into the primary grade program. Directions are simple and brief yet, with the accompanying sketches, are adequate so that the teacher inexperienced in science is enabled to see just what should be done. Most of the experiments may be carried out with easily obtainable materials such as milk bottles, tin cans, sterno stoves, etc. This is not so much a text or workbook as a sourcebook of tested experiments to be used to supplement the elementary science texts and readers now on the market, and so classified that they become not mere isolated activities, but a means to an end. The reviewer feels that this series should prove one of the most valuable aids so far published for the average classroom teacher who wishes to carry on a modern program of elementary science. Much material has been written to aid the teacher in handling the biological materials, but very little in the physical science field. —O. E. Underhill.

Hudspeth, Jack and Hudspeth, Frances H. *Elementary Science Workbooks and Handbook for Teachers.* Austin, Texas: The Steck Company, 1938.

Only Books 5 and 6 of a series of seven books are as yet available. The first named author is coordinator of science and the second a teacher of science in the Austin Texas Public Schools.

According to the authors "each workbook introduces in its proper grade level the essential science concepts. These concepts are repeated in the higher levels with a more advanced and complex point of view—Materials having a social value are given preference over those which are merely interesting. Each workbook contains sufficient text material for a year's work, and an abundance of exercises, activities and tests—Each book is profusely illustrated."

A Teachers Manual accompanies each workbook and there is a general Teachers' Handbook as well. The Manuals and Handbook present many suggestive approaches and techniques, simple experiments, suggestions for field trips and seasonal activities, visual aids, and readings. Whatever the teaching method employed, ele-

mentary science teachers will find some valuable material in these workbooks and manuals.

Handbook for Teachers, 76 p.................$0.50
Elementary Science Book 5, 112 p...........$0.35
Teachers Manual for Book 5, 60 p...........$0.35
Elementary Science Book 6, 120 p...........$0.35
Teachers Manual for Book 6, 40 p...........$0.35

—C.M.P.

KILANDER, H. F. *Health Knowledge of High School and College Students.* Reprint from the *Research Quarterly*, October, 1937, Vol. 8, No. 3, 32 p. $0.25.

A report on the testing of 2900 high school students, college students, and adults with the Kilander Health Knowledge test. Complete data are given with an analysis of selected questions followed by the recommendations: (1) for further study (2) for a more important place for health education in the schools, (3) for an analysis of other subjects to determine the contribution to be expected of them. —L.M.S.

SYMPOSIUM. *Modern Wonder Books.* Columbus: American Education Press. $8.75 for set, or $0.15 each.

The books listed below comprise a complete classroom library. Each book comprises a single unit with stated organizing theme, generalizations and learning elements. Particular attention has been paid to vocabulary and reading difficulty. The authors include many persons well-known in the elementary science field. As a whole the list comprises a well-selected group of elementary social science readers. A Teacher's classroom library manual accompanies the set.

First Grade Books

Eleanor M. Johnson. *Travel, Policemen, Firemen, Keeping Our City Safe and Clean, Dairy, Farm Animals, Pets, The Circus, Our Houses, Library.*
Frances Everhart and Mae McCrory. *How Animals Travel.*
Vesta Withrow. *The Story of Seeds.*
Ethel I. Summy. *The Zoo.*
Isabelle U. Freeland. *Animal Families.*
Reta D. McDonough. *Birds and Their Babies.*

Second Grade Books

Doris D. Klaussen. *Your Shoes and Your Feet, Pueblo Indians.*
Ruth V. Angelo. *Eskimos.*
Mae McCrory. *Milk, Plants That Give Us Food, Clothes, Man's Animal Helpers, Where Animals Live.*
Eleanor M. Johnson. *Cowboys, Life in the Sea.*
Wilhelmina Slootmacher. *The Post Office, Early Man and the Animals.*
Jeanette Smith. *Animals and Their Babies, Simple Machines, Sun, Moon and Stars.*

Third Grade Books

Beatrice J. Hurley. *Trains, Flying, Boats.*
Helen M. Cooper. *Glass and Bricks.*
Doris D. Klaussen. *Heat.*
Marion S. Wheeler. *The Story of Paper.*
Ida T. O'Keefe. *Forest Indians.*
Jeanette Smith. *Pets at School.*
Ethel K. Howard. *Coal.*
Marguerite Bigler. *Navajo Indians.*
Mary Belle Herring. *The Story of Frogs.*
Gaynelle Davis. *Protection in Nature.*
Grace Alder. *The Seasons.*
Claude R. Hill. *How Birds Live.*
Frances Lacy. *What Animals Eat.*

Fourth Grade Books

Anna M. Greve. *Soil.*
Ruth G. Strickland. *Bees and Ants.*
Thelma Greenwood. *Indoor Gardens.*
Metta G. Philbrick. *Electricity and Magnets.*
Walter R. Fee and Violet Fee. *The Greeks, Romans, Egyptians.*
Della Van Amburgh. *Silk, Communication, Light.*
Ethel K. Howard. *Time.*
Edna M. Reed. *Beginnings of Trade.*
Odille Ousley. *Hot, Dry Lands.*
Irene Kaplon and Gerald Raferty. *Vikings.*

Fifth Grade Books

Kristin Nilsson. *Water.*
Alida Hurtebise. *Irrigation.*
Dorothy Greenleaf. Growth of Cities.
Maria E. Johnson and W. D. Hines. *Rubber.*
Tolosa Cooke. *Corn.*
Sallie B. Marks. *Cotton.*
Lydia J. Trowbridge. *Transportation.*
Violet Fee and Walter R. Fee. *Winning the West.*
Della Van Amburgh. *Colonial Life.*
Doris D. Klaussen and Irene Eisele. *Early Explorers.*
John C. Almack. *Knighthood.*

Sixth Grade Books

Daisy Grenzow. *World Trade.*
Alila Hurtebise. *Inventions.*
Doris Davis Klaussen. *Modern Explorers.*
Martha F. Sager. *Newspapers.*
Clara L. Tutt. *Fisheries.*
Eleanor Thomas. *The Story of Money.*
John C. Almack. *Homes, Old and New.*
Lydia J. Trowbridge. *Cereals.*
Ethel K. Howard. *Lumber.*
Walter R. Fee and Violet Fee. *Japan Today.*

—C.M.P.

BROWNELL, CLIFFORD LEE, IRELAND, ALLEN GILBERT, GILES, HELEN FISHER, AND TOWNE, CHARLES FRANKLIN. *Health and Safety Series.* New York: Rand McNally and Company, 1935.

The materials in this excellent series of books are organized in units that center around life situations. In each unit, emphasis is on things within the range of the experiences of children, on the things they can do, and on knowledge and attitudes that are inherent in good living. The books are written in an attractive easy style that children will enjoy. Although the authors consistenty address pupils, there are implied suggestions for the teacher throughout the books. The illustrations are excellent drawings in color and photographs that are intimately tied up with the reading materials. At the close of each book is a glossary to assist pupils with pronunciation and meaning of unfamiliar words, a list of books, magazines, and free booklets, and directions for using an encyclopedia for additional informational materials. Included in the third book of the series, *Helpful Living*, is a measuring scale for weight in relation to age, height, and physical type. Eye strain of the reader is lessened by clear bold print. The washable covers are in harmony with principles of health education.

Everyday Living. 218 p. $0.45.
This book is written for children on the fifth grade

level. The materials center around such topics as planning the school-day, the hours of play, enjoying your work, the foods you eat, the house where you live, and when someone is ill.

Helpful Living. 232 p. $0.48.

This book is intended for pupils in the sixth grade. The materials are organized around topics, such as going to school, taking care of your health, living in the community, working together, having good times, and fighting disease.

Science in Living. 248 p. $0.54.

This book is written for seventh grade pupils. The units are organized around centers, such as getting better acquainted with things, knowing your body, eating and growing, getting rid of waste materials, the nervous system and the special senses, keeping the body well, and teamwork in health.

Progress in Living. 264 p. $0.57.

This book is appropriate for children in the eighth grade. Its materials are organized around units, such as the following: living with the help of science, making places comfortable and inviting, dangers in winter, food and water, health and medicine, health protection in public places, working together for health and recreation, and teamwork in government and community.

—F.G.B.

DITMARS, RAYMOND L. AND BRIDGES, WILLIAM. *Wild Animal World: Behind the Scenes at the Zoo.* New York: D. Appleton-Century Company, 1937. 304 p. $3.00.

Few of the large numbers of people who visit zoölogical parks ever have an opportunity to see the normal everyday life in such institutions. They little realize the tremendous effort and painstaking care required in collecting animals and providing them with proper housing facilities, food, and the necessary medical attention.

In *Wild Animal World* the authors present inside pictures of many phases of activities common in one great American zoölogical park. They share with their readers some of the thrills in catching and transporting wild animals; some understanding of proper methods of housing animals, feeding and taking care of them in health and in sickness, and an insight into many interesting reactions wild animals make to their new environment. The authors also clarify many myths and superstitions prevalent about animal life.

Twenty-eight excellent photographs add to the interest and attractiveness of this delightfully written book which will be enjoyed by boys and girls in later elementary and secondary school grades as well as by adults. It is a valuable contribution to literature about animals.

—F.G.B.

DITMARS, RAYMOND L. *The Making of a Scientist.* New York: The Macmillan Company, 1937. 258 p. $2.75.

This book is, in part, the autobiography of Dr. Ditmars, a scientist well known through his work as Curator of Mammals and Reptiles at the New York Zoölogical Park, as an outstanding authority on reptiles, as an author, and as a lecturer of note.

In reading the book one becomes acquainted with many of the enjoyments, thrills, and disappointments experienced by a scientist. One meets a boy keenly interested in animal life who wanted pets so much that he used his lunch money to buy them. This compelling desire to have animals that he could take care of, observe, and enjoy, led him into many difficulties, such as gaining and retaining the approval of his family, difficulties arising with neighbors who objected to housing animals on the fire escape, and problems of feeding and making his pets comfortable. The reader learns how this desire to work with animals led to a position in the Museum of Natural History. The author's early and varied interests were not confined to animals. His interest in weather persisted throughout life and led him into studying, observing, and experimenting, and to the lecture hall. The reader cannot help but gain some idea of the importance of knowing the why of things and not being satisfied with seeing only what is going on.

Several chapters are devoted to experiences with the diamond-back rattlesnake, spike-tailed lizard, horned toad, monkeys, quest of the giant bat, dew in the desert, a hurricane, the whys of a snowstorm, the paradox frog, and the first bushmaster in captivity.

This stimulating book is well illustrated by many excellent and appropriate photographs. It is written in a fascinating style that will attract young people of junior- and senior-high-school age as well as adults. It should find a place in every secondary school and public library.

—F.G.B.

DITMARS, RAYMOND L. *The Fight to Live.* New York: Frederick A. Stokes Company, 1938. 232 p. $2.50.

The fight to live began millions of years ago and has continued throughout geological history. During this time there has been a rise and fall of many devices used in attack and in protection. Some devices have survived almost unchanged while others have been modified to meet changing conditions. The struggle to live among present day animals goes on with "a mixture of attacking powers, protective devices, a battle of wits and toil."

In *The Fight to Live,* Dr. Ditmars begins with a discussion of man's struggle for existence and continues with other topics, such as the anthropoid apes and monkeys; teeth, claws, horns, antlers, spines, and armor; the lives of beavers and their kin; among the birds; down the scale to the reptiles; poisonous snakes and their enemies; the struggle of the amphibians; the defenses of fishes; smoke screens, poison gas, and camouflage; in the world of make-believe; and disciplined warfare long before man. Dr. Ditmars repeatedly indicates that man's modern methods of defense have been copied or have received their inspiration from defenses used by animals of today as well as from those of ages ago.

This book is a valuable contribution to litera-

ture relating to animal life. It gives accurate information about animals. It has the advantage of having been written by an eminent authority on the habit of animals. It is interesting because of the point of view presented and the fascinating style of the author. It is beautifully illustrated by fifty-three photographs which form an integral part of the story. The book will appeal to young people of secondary school age and adults.

—F.G.B.

HAWKES, CLARENCE. *Notes of a Naturalist.* Boston: The Christopher Publishing House, 1938. 127 p.

There are no illustrations, but the word pictures of intimate experiences of the author captivate the nature lover. —W.G.W.

PATCH, EDITH M. AND FENTON, C. L. *Forest Neighbors.* New York: The Macmillan Company, 1938. 198 p. $1.50.

The book tells about experiences one might have in the north woods from Maine to Minnesota. Many interesting habits of wild life are interestingly told. There are stories of the fox, the hare, the lynx, the deer, the bear, the squirrel, the marten, the loon, the beaver, the tree-frog, the snowshoe rabbit, and of many birds. The illustrations include 48 excellent line cuts—drawings of animals and plant leaves with fruit—and 6 half-tones. —W.G.W.

MCCLINTOCK, THEODORE. *The Under Water Zoo.* New York: The Vanguard Press, 1938. 111 p. $1.75.

This is a series of fascinating stories of the author's experiences with his aquarium. He tells how he stocked it and describes the activities he has observed. They have been many and some of them very unusual. It is about community life of beetles, dragonflies, nymphs, scuds, dragons, tads, snails, and striders. There are 25 drawings. —W.G.W.

KING, ELEANOR AND PESSELS, WELLMER. *Insect Allies.* New York: Harper and Brothers, 1938. 45 p. $1.25.

This little book gives interesting accounts of more than six common insects and stories of some of our insect hobbyists. There are twenty pages of excellent illustrations, not included in the 45 pages of text. Unfortunately, the book lacks both table of contents and index.

—W.G.W.

ROSE, MARY S. AND BOSLEY, BERTLYN. *Our Cereals—A Nutrition Unit for the Fourth, Fifth, and Sixth Grades of the Elementary School.* New York: Bureau of Publications, Teachers College, Columbia University, 1938. 34 p. $0.35.

A large part of the money earned by most people is spent for food. The degree of success in spending this money is dependent upon the ability of the purchaser to choose an adequate diet within the limits of his food budget. Since the science of nutrition has developed to the point "where it can be practically and effectively applied to everyday living," the schools have an opportunity to aid in the improvement of general health in the country by means of "carefully planned, consistent, and continuous education in nutrition in elementary and junior high schools."

Suggestive of a way in which this might be done, the authors of this booklet have outlined in detail twelve lessons for a nutrition unit which has been developed and tried out with children in grades four, five, and six in elementary schools. The materials for each lesson are organized under the headings—subject, objective, procedure, and materials needed. A list of suggestive riddles is given for lesson twelve. The authors have included also a bibliography of books for children and teacher and a list of commercial materials that may be useful in developing the unit.

This study is significant for teachers and curricular workers in elementary schools.

—F.G.B.

SYMPOSIUM. 1938 *Proceedings Department of Science Instruction of the N. E. A.* Mayville, North Dakota: George J. Skewes, 1938. 165 p. $0.50.

The general theme of the 43rd annual meeting held at New York City, June 27–30, 1938, was making science a more significant factor in living. The papers presented and the authors were as follows: (1) "Functional Values of Science," by Charles J. Pieper, (2) "Measuring the Results of Science Teaching," by Warren W. Knox, (3) "Demonstration of Some Aids to Reflective Thinking," by John A. Clark, (4) "The Brooklyn Botanic Garden and Its Contribution to Elementary Science," by Ellen Eddy Shaw, (5) "Vitalizing Science through Teacher Training," by Anna M. Gemmill, (6) "Demonstrations and Their Function in the Science Program," by Margaret L. Wilt, (7) "Back to the Soil," by Helen M. Strong, (8) "A Science Program in the First Six Grades Based on the Social and Individual Needs of New York City Children," by Rebecca Brown, (9) "Science Units for Primary Grades," by Geraldine Peterson, (10) "A Science Unit in the Intermediate Grades," (11) "Fifty Educators' Comment on Elementary Science," by David W. Russell, (12) "The Real Need of Standard Tests in the Junior High School," by James T. Hepinstall, (13) "Teaching Appreciation in the Junior High School," by Ruth Tiedeman, (14) "Radio Trends in Broadcasting of Science," by Harold W. Kent, (15) "Adapting Biology Courses to Pupil Interests," by Carleton B. Moose, (16) "Specialized General Science Courses in the Junior High School," by Franklin T. Mathewson, (17) "The Integration of Science and Handwork," by Louis V. Newkirk, (18) "Attitudes and Their Relation to Science Instruction," by Paul B. Mann, (19) "Teacher Hobbies for the Improve-

ment of High School Science," by James Kezer, (20) "How the Interest of Parents May be Increased by Means of Student Projects," by Sarah Bent Ransom, (21) "Building the Science Program Up or Down," by Donald D. Pettit, (22) "Conservation Problems in the High School," by Richard Weaver, (23) "A Fused Physical Science Course," by Alfred A. Dart, (24) "Assemblies and High School Science." Miss Mildred Fahy led a panel discussion on "The Emphasis of the Science Program Shall be Placed on (1) Principles," by Philip G. Johnson, (2) "Applications," by S. R. Powers, (3) "Appreciations," by George J. Skewes, (4) "Scientific Methods and Attitudes" by Elsie Flint Neuner, (5) "Logical Organization" by Louis J. Mitchell and (6) "Functions" by O. E. Underhill." —C.M.P.

RAMSEY, GRACE FISHER. *Educational Work in Museums of the United States. Development, Methods, and Trends.* New York: The H. W. Wilson Company, 1938. 289 p. $2.50.

The number of museums in the United States has increased steadily since 1773 when the first one was established in Charleston, South Carolina. During the last twenty-five years, however, the number founded has almost doubled. The educational work of present-day museums takes on new significance when it is realized that from twenty to thirty million people visit museums annually and that one large museum made forty million contacts in one year.

This book gives the first detailed account of the educational work of museums in the United States. The author speaks with authority because of her background of extensive experience acquired during nineteen years of association with the American Museum of Natural History in New York City; because of her many interviews with museum directors and those immediately in charge of educational work; and because of her visits to more than one hundred forty museums during 1936–1938. She considers the work of museums from the earliest efforts at organized programs to the present elaborate ones that include educational work relating to adult education, teacher training, museum work with organized school classes and with handicapped children, individual children, development of field trips and nature trails, extension work, museum and radio, the educational staff of museums, and relations to and evaluation of educational work in museums. In addition, the author includes a comprehensive bibliography of literature relating to museums and a list of museums visited.

No museum worker can afford to be without this important study. It is also invaluable for teachers who realize the importance of the museum as an integral part of the educational program in this country. —F.G.B.

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